AMERICAN SOCIETY
FOR
TESTING MATERIALS

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS
OF THE
THIRTY-FIFTH ANNUAL MEETING

Held at Atlantic City, N. J.
June 20-24, 1932

VOLUME 32

PART I. COMMITTEE REPORTS
NEW AND REVISED TENTATIVE STANDARDS
TENTATIVE REVISIONS OF STANDARDS

PUBLISHED BY
AMERICAN SOCIETY FOR TESTING MATERIALS
1315 Spruce Street, Philadelphia, Pa.

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Printed in Philadelphia, U. S. A.
December, 1932

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American Society for Testing Materials

PROCEEDINGS, PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

SUMMARY OF THE PROCEEDINGS OF THE THIRTY-FIFTH ANNUAL MEETING

ATLANTIC CITY, N. J., JUNE 20–24, 1932

THE THIRTY-FIFTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at Chalfonte-Haddon Hall, Atlantic City, N. J., June 20–24, 1932. The following is an analysis of the registered attendance at the meeting: Members in attendance or represented, 588; guests, 86; total, 674; ladies, 82.

A Round Table Discussion on Acquisition of Good Data was held on Monday evening, June 20 at 8 p. m. and continued on Tuesday, June 21, at 10 a. m. The discussion was introduced by the following program of papers organized and sponsored by the Committee on Presentation of Data of Committee E-1 on Methods of Testing:

"Statistical Nature of A.S.T.M. Data," by R. F. Passano.
"Specifications of Standards of Quality," by N. F. Harriman.
"Inspection Specifications," by G. D. Edwards.
"Need for Control in Sampling Inspection," by H. F. Dodge.
"Criteria for Rejection of Observations," by P. R. Rider.
"Methods of Dealing with Discordant Observations," by E. W. Washburn.
"Elimination of Systematic Errors," by H. C. Dickinson.
"Rôle of Statistical Method in Economic Industrial Standardization," by W. A. Shewhart.

In introducing this first general discussion before the Society on the subject of good data W. H. Fulweiler and Anson Hayes, chairmen of the round-table discussion, reviewed briefly the activities of the committee and the purpose in arranging this program to discuss the fundamental scientific problems of methodology that must be considered in the establishment of a basis for stating the requirements of good data and the methods to be followed in acquiring good data.

FIRST SESSION—TUESDAY, JUNE 21, 10 A. M.

Reports of Administrative Committees; Nomenclature and Testing

President F. O. Clements in the chair.

President Clements in opening the Thirty-fifth Annual Meeting reviewed briefly the accomplishments of the Society during the year. In citing the effect of present-day conditions on membership, finances, publications and activities of the Society he called attention to the number of committee reports as indicating that there had been no curtailment in the standardization and research work of the committees. In fact, the reports showed an increased interest in fundamental research of materials and President Clements expressed the wish that the Research Fund of the Society would soon be enlarged in order that this work might be continued on an even more extensive scale.

The minutes of the Thirty-fourth Annual Meeting were approved as printed in the 1931 *Proceedings*.[1]

The President appointed a Committee of Tellers consisting of L. W. Olson, chairman, and Sam Tour to canvass the vote on the election of officers, the report of the tellers to be received at the Annual Meeting Dinner on Wednesday evening.

The report of Committee E-6 on Papers and Publications was presented by the Assistant Secretary, and on motion was adopted.

The report of Committee E-9 on Research was presented by the chairman, H. F. Moore, and on motion was adopted.

The report of Committee E-10 on Standards was presented by the chairman, T. R. Lawson, and on motion was adopted.

The report of the Executive Committee was presented by the Secretary-Treasurer, C. L. Warwick. The report discussed membership, finances, regional and district committee meetings, activities of numerous standing committees, including organization of three new committees, publications, publicity and promotional activities, and administrative matters concerning relations with other societies and international relations on various standardization projects. A revision of Section 4, Article I of the By-laws to make Student Membership in the Society available to all undergraduate students in technical schools of recognized standing, and an amendment to Section 2, Article VIII to provide an entrance fee for Sustaining Members, recommended by the Executive Committee were approved for reference to letter ballot of the Society for adoption. On motion, the report of the Executive Committee was adopted.

A paper entitled "Full-Load Calibration of a 600,000-lb. Testing Machine," by H. F. Moore, J. C. Othus and G. N. Krouse was presented by Mr. Moore.

A paper entitled "An Automatic Autographic Extensometer for Use in Tension Tests of Materials," by R. L. Templin was presented by the author.

The report of Committee E-1 on Methods of Testing was presented by the chairman, W. H. Fulweiler. In presenting the report Mr. Fulweiler called on H. F. Moore to present the report of the Technical Committee on Mechanical Testing and on G. S. Haslam to describe the work of the Technical Committee on Size and Shape. On motion, the report was adopted.

An informal report on the organization of the Sectional Committee on Sieves for Testing Purposes was presented by the Assistant Secretary.

The report of Committee E-8 on Nomenclature and Definitions was presented by the secretary, R. E. Hess. The approval by Committee E-8 for adoption as standard of the revised definitions of the terms bitumens, asphalts, flux, tars, and pitches was reported. On motion, the report was adopted.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 13 (1931).

The meeting then adjourned till 2 p. m.

SECOND SESSION—TUESDAY, JUNE 21, 2 P. M.

Textile Materials

(Held Simultaneously with Third Session)

Mr. Dean Harvey in the chair.

The report of Committee D-13 on Textile Materials was presented by the chairman, H. J. Ball. The proposed Tentative Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 - 29) and for Cotton Sewing Threads (D 204 - 27) were accepted for publication as tentative. The proposed revision of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 31 T) was accepted, the specifications as revised being continued as tentative. The committee withdrew its recommended revision of the Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 - 30) and also its recommendation for advancement to standard of the Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 - 27 T) which appeared in the report as preprinted. On motion, the report as amended was adopted.

The following papers on textile materials were then presented by their respective authors:

"A Machine Test on the Durability of Manila Rope," by N. C. Wiley.

"Enzyme Action in the Textile Industries," by W. F. Edwards.

"Atmospheric Control in the Textile Industry," by R. H. Brown—presented from manuscript.

"Asbestos Textiles," by C. K. Dillingham.

"Some Aspects of the Structure and Properties of the Rayons," by H. DeW. Smith.

"The Suter-Webb Cotton Fiber Duplex Sorter and the Resulting Method of Length-Variability Measurements," by R. W. Webb—presented from manuscript.

"Colorimeter and Method Employed in the Color Testing of Cotton," by Dorothy Nickerson.

The meeting then adjourned till 8 p. m.

THIRD SESSION—TUESDAY, JUNE 21, 2 P. M.

Symposium on Steel Castings

(Joint Session with American Foundrymen's Association)

(Held Simultaneously with Second Session)

President Clements extended a cordial welcome to the members of the American Foundrymen's Association at this joint session of the A.F.A. and A.S.T.M. devoted to a Symposium on Steel Castings arranged under the auspices of the two societies.

The President then introduced R. A. Bull, Past-President of the A.F.A. who, as representative of T. S. Hammond, President of the American Foundrymen's Association, expressed appreciation on behalf of the A.F.A. for the opportunity of cooperating in this joint session on a subject of vital interest to both Societies.

The President then presented H. F. Moore and W. C. Hamilton, co-chairmen of the joint session. The following five papers comprising the first half of the Symposium were then presented:

"General Survey of the Steel Castings Industry," by W. C. Hamilton—presented by the author.

"Statistical Data on Steel Casting Production in the United States," by G. P. Rogers—presented by the author.

"Notes on the Design of Steel Castings," by F. A. Lorenz, Jr.—presented by the author.

"Purchase Requirements for Steel Castings, with Notes on Physical Properties in Test Bars and in Commercial Castings," by R. A. Bull—presented by the author.

"Physical and Mechanical Properties of Cast Steels," by C. H. Lorig and C. E. Williams—presented from manuscript by Mr. Lorig.

The meeting then adjourned till 8 p. m., the Symposium being continued in the Fourth Session.

FOURTH SESSION—TUESDAY, JUNE 21, 8 P. M.

Symposium on Steel Castings

(Joint Session with American Foundrymen's Association)

(*Continued from Third Session*)

Messrs. Zay Jeffries and W. C. Hamilton in the chair.

The Symposium on Steel Castings which had been opened in the Third Session was continued in this session with a group of three papers on the development of alloy steels for castings and two papers covering, respectively, heat treatment and welding of castings, as follows:

Development of Alloy-Steels for Castings:

(*a*) "Representative Properties of Cast Medium Pearlitic Steels," by Fred Grotts—presented by P. E. McKinney.

(*b*) "Castings of Corrosion-Resistant Steels," by Jerome Strauss—presented from manuscript by the author.

(*c*) "Austenitic Manganese Steel Castings," by John Howe Hall—presented by the author.

"Problems and Practices in the Heat Treatment of Steel Castings," by A. W. Lorenz—presented by the author.

"Fusion Welding as Related to Steel Castings," by T. S. Quinn—presented by R. A. Bull.

In closing this joint session of the A.F.A. and A.S.T.M. on Steel Castings, Mr. Jeffries called attention to the valuable service which the data in the symposium sponsored by the two Societies will be to industry. He paid tribute to the committee under the chairmanship of W. C. Hamilton which had arranged for the preparation of the papers and to the excellent presentations made by the authors of the various papers.

The meeting then adjourned till the following morning.

Fifth Session—Wednesday, June 22, 9.30 a. m.

Steel, Wrought Iron, Magnetics

(*Held Simultaneously with Sixth Session*)

President F. O. Clements in the chair.

The report of Committee A-4 on Heat Treatment of Iron and Steel was presented from manuscript by the secretary, John Howe Hall. A new definition of the term "nitriding" and the proposed revisions of the terms "heat treatment," "annealing," "normalizing," and "tempering," in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 30), were accepted for publication as tentative. On motion, the report was adopted, subject to a favorable letter ballot of Committee A-4.[1]

The report of Committee A-9 on Ferro-Alloys was presented by the secretary, Charles McKnight. The proposed Tentative Specifications for Ferro-Tungsten, for Low-Carbon Ferro-Molybdenum, and for Molybdenum Salts and Compounds, and Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum were accepted for publication as tentative. On motion, the report was adopted.

The report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys was presented by the chairman, Jerome Strauss and on motion was adopted.

The report of Committee A-1 on Steel was presented by the chairman, J. B. Young. The proposed Tentative Specifications for Structural Rivet Steel, and for Electric-Fusion-Welded Steel Pipe were accepted for publication as tentative.

The proposed Tentative Specifications for Structural Medium Steel were accepted for publication as tentative with the following change in the scope clause subject to a favorable letter ballot of Committee A-1:[2]

Scope.—Change the first sentence of the scope clause in the specifications as preprinted:

> "These specifications cover structural steel of a higher tensile strength than that designated in the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) and the Standard Specifications for Structural Steel for Buildings (A.S.T.M. Designation: A 9) of the American Society for Testing Materials and may be used when such higher strength is desired."

to read as follows:

> "These specifications are issued to supply standardized requirements for a constructional steel not usually carried in stock but occasionally specified for special work of heavy character; and that has an average tensile strength greater than the standard structural grade in general use."

The proposed revisions of the Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24), for Quenched Carbon-Steel Track Bolts (A 50 – 24), for Quenched Alloy-Steel Track Bolts (A 51 – 21), for Steel Screw Spikes

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[1] The report was submitted to letter ballot of the committee which consists of 47 members; 26 members returned their ballots of all whom have voted affirmatively.

[2] The revision was submitted to letter ballot of the committee which consists of 190 members; 113 members returned their ballots of whom 91 have voted affirmatively and none negatively.

(A 66 - 21), for Steel Tie Plates (A 67 - 30), for Low-Carbon-Steel Track Bolts (A 76 - 27), for Structural Steel for Buildings (A 9 - 29), for Billet-Steel Concrete Reinforcement Bars (A 15 - 30), for Rail-Steel Concrete Reinforcement Bars (A 16 - 14), for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 27), for Welded and Seamless Steel Pipe (A 53 - 30), for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 30), for Hot-Rolled Bar Steels (A 107 - 30), for Cold-Finished Bar Steels and Shafting (A 108 - 30) and for Steel Plates of Structural Quality for Forge Welding (A 78 - 30) were accepted for publication as tentative.

The proposed revisions of the Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 31 T), for Black and Hot-Dipped Zinc-Coated Steel Pipe for Ordinary Uses (A 120 - 28 T), for Electric-Fusion-Welded Steel Pipe (A 134 - 31 T), for Electric-Resistance-Welded Steel Pipe (A 135 - 31 T), for Forge-Welded Steel Pipe (A 136 - 31 T), for Lock-Bar Steel Pipe (A 137 - 31 T), and for Riveted Steel and Wrought-Iron Pipe (A 138 - 31 T) were accepted, the specifications as revised being continued as tentative.

In addition to the proposed revision, as preprinted, in the Tentative Specifications for Soft Steel Track Spikes (A 65 - 26 T), the committee recommended the following revision in the specifications which was also accepted, subject to a favorable letter ballot of the committee,[1] the specifications as revised to be continued as tentative:

Tension Tests.—Add the following optional tension test requirements as a new Section 4 under the heading Physical Properties and Tests and renumber the present Sections 4 to 9 accordingly:

> "4. (*a*) *Tensile Strength*.—The manufacturer may, at his option, substitute tension tests for the chemical analysis specified in Section 2, in which case the finished spikes shall conform to the following minimum requirements as to tensile properties:
>
> | | |
> |---|---|
> | Tensile strength, lb. per sq. in. | 55 000 |
> | Yield point, lb. per sq. in. | 0.5 tens. str. |
> | Elongation in 2 in., per cent | 25 |
>
> (*b*) When this option is exercised, one tension test shall be made from each 10-ton lot or fraction thereof."

The withdrawal of the Standard Specifications for Extra-High-Carbon-Steel Splice Bars (A 6 - 14) was approved. On motion, the report as amended was adopted.

A paper entitled "The Testing of Rope Wire and Wire Rope," by A. V. de Forest and L. W. Hopkins, was presented by Mr. Hopkins.

The report of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing was presented by the chairman, H. H. Morgan. On motion, the report was accepted for publication.

The report of Committee A-2 on Wrought Iron was presented by the vice-chairman, James Aston. The proposed revision, with respect to provisions for wrought iron, of the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 - 31 T) was accepted, the specifications as revised being continued as tentative. On motion, the report was adopted.

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[1] The revision was submitted to letter ballot of the committee which consists of 190 members; 113 members returned their ballots of whom 71 have have voted affirmatively and 2 negatively.

The report of Committee A-6 on Magnetic Properties was presented by the secretary, R. L. Sanford. The proposed revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28) was accepted for publication as tentative. On motion, the report was adopted.

A paper entitled "A Correlation of Some Mechanical and Magnetic Properties of 1.21-per-cent Carbon Tool Steel," by J. V. Emmons and R. L. Sanford, was presented by Mr. Sanford.

The meeting then adjourned till 4 p. m.

SIXTH SESSION—WEDNESDAY, JUNE 22, 9.30 A. M.

Rubber, Paints, Petroleum Products and Electrical Insulating Materials

(Held Simultaneously with Fifth Session)

Mr. R. L. Hallett in the chair.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, T. A. Boyd. A progress report of Technical Committee C on Fuel Oils (including Diesel Fuel) was presented for inclusion in the report. The proposed revisions of the Standard Methods of Test for Flash and Fire Points by Means of Open Cup (D 92 – 24) and Test for Cloud and Pour Points (D 97 – 30) were accepted for publication as tentative, with the following editorial changes in the latter method:

Section 11.—Add the words "and the assembly placed in the jacket," at the end of the third sentence of the third paragraph.

> Add the following sentence at the end of the third paragraph:
>
> "Oils on which a pour point of above 90° F. is expected shall be heated to 115° F. or to a temperature 15° F. above the expected pour point, with the high cloud and pour test thermometer in position, and the test jar immediately introduced into the jacket."

The following proposed revision of the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30), not included in the report as preprinted, was accepted for publication as tentative, subject to a favorable letter ballot of Committee D-2:[1]

Section 3 (b).—Change the 212° F. test temperature with the Saybolt Furol Viscosimeter to 210° F., thus making this paragraph read as follows by the addition of the figures in italics and the omission of those in brackets:

> "(*b*) With the Saybolt Furol Viscosimeter, determinations shall be made at 77, 122 or [212] *210*° F. (25, 50 or [100] *98.9*° C.)."

The proposed revisions of the Tentative Methods of Test for Color of Lubricating Oils by Means of Union Colorimeter (D 155 – 23 T), for Color of Petrolatum by Means of Union Colorimeter (D 218 – 25 T), for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 30 T) and for Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 31 T) were accepted, the methods as revised being continued as tentative.

The advancement to standard of the tentative revision of the Standard Method of Test for Distillation of Natural Gas Gasoline (D 216 – 30) was approved for reference to letter ballot of the Society for adoption. On motion, the report as amended was adopted.

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[1] The revision was submitted to letter ballot of the committee which consists of 103 members; 55 members returned their ballots of whom 54 have voted affirmatively and none negatively.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by the secretary, P. H. Cathcart. The proposed Tentative Specifications for Ethylene Glycol Mono Butyl Ether, for Ethylene Glycol Mono Ethyl Ether, for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent Grade), and for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent Grade), and Method of Test for Comparative Hiding Power of Paints were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Basic Carbonate White Lead (D 81 - 31) and of the Standard Methods of Routine Analyses of White Pigments (D 34 - 30), of White Linseed Oil Paints (D 215 - 29), of Dry Red Lead (D 49 - 29), of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 27), of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 27), of Titanium Pigments (D 186 - 29), of Dry Cuprous Oxide (D 283 - 29), of Dry Mercuric Oxide (D 284 - 29), and Test for Hygroscopic Moisture in Pigments (D 280 - 31), were accepted for publication as tentative.

The proposed revisions of the Tentative Specifications for Glazier's Putty (D 317 - 30 T) and Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 31 T) were accepted, the specifications and methods as revised being continued as tentative.

The committee withdrew the report of Subcommittee XIII on Shellac and its recommendation for publication as tentative of the Specifications for Shellac Varnish and proposed revisions of the Tentative Specifications for Dry Bleached Shellac (D 207 - 29 T), and Methods of Sampling and Testing Shellac (D 29 - 29 T), which appeared in the report as preprinted. On motion, the report as amended was adopted.

A paper entitled, "An Example of Long-Time Service of Baked Enamel Coating on Water Pipe," by A. H. Sabin was presented by the author.

The report of Committee D-11 on Rubber Products was presented by the acting chairman, C. R. Boggs. The proposed Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound were accepted for publication as tentative, with the addition of a new section covering cotton braid subject to a favorable letter ballot[1] of Committee D-11.

The proposed Tentative Specifications for Friction Tape for General Use for Electrical Purposes were accepted for publication as tentative to supersede the present Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 - 28), the withdrawal of which specifications was accordingly approved.

In presenting the proposed revision of the Tentative Specifications for Rubber Insulating Tape (D 119 - 28 T), the committee recommended the omission from the revised specifications of the maximum tensile strength requirement of 500 lb. per sq. in. The proposed revised specifications were accepted, the specifications as revised being continued as tentative.

The advancement to standard of the Tentative Methods of Chemical Analysis of Rubber Products (D 297 - 31 T) was approved for reference to letter ballot of the Society for adoption. The advancement to standard of the tentative revisions in the Standard Methods of Testing Rubber Products (D 15 - 24) and the deletion from the methods of the procedures for chemical analysis were approved for reference to letter ballot of the Society for adoption, the methods as revised to be continued as standard. On motion, the report as amended was adopted.

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[1] The required favorable letter ballot on this proposed addition to the specifications was not obtained.

The report of Committee D-9 on Electrical Insulating Materials was presented by the secretary, J. A. Scott. The following recommendations of the committee were approved subject to a favorable letter ballot[1] of Committee D-9:

The Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation, and Test for Grading Natural Mica According to Size, Commercial Quality and Thickness were accepted for publication as tentative. The proposed revisions of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 30) and of Testing Electrical Insulating Oils (D 117 - 31) were accepted for publication as tentative.

The proposed revisions of the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 - 31 T), of Testing Untreated Paper Used in Electrical Insulation (D 202 - 30 T), of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T), of Testing Electrical Insulating Materials for Resistance to Impact (D 256 - 28 T), and of Test for Resistivity of Insulating Materials (D 257 - 29 T) were accepted, the methods as revised being continued as tentative. On motion, the report was adopted subject to a favorable letter ballot[2] of Committee D-9.

A paper entitled "Application of Control Analysis to the Quality of Varnished Cambric Tape," by M. F. Skinker was presented by the author.

The meeting then adjourned till 4 p. m.

SEVENTH SESSION—WEDNESDAY, JUNE 22, 4 P. M.

Edgar Marburg Lecture

President F. O. Clements in the chair.

The President, in opening the session, explained briefly the purpose for the institution of the Edgar Marburg Lecture established in 1926 to commemorate the first Secretary-Treasurer of the Society, Edgar Marburg. President Clements paid tribute to the fine character and high ideals of Mr. Marburg whose vision, ambition and energy have contributed so much to the character of the Society and its development.

The President then introduced the seventh Edgar Marburg Lecturer, Dr. Hugh Stott Taylor, Head of Chemistry Department, Princeton University, who chose as the subject of the lecture: "Fundamentals in the Problem of Resistance to Deterioration."

WEDNESDAY, JUNE 22, 7 P. M.

Annual Meeting Dinner

Past-President G. H. Clamer, Toastmaster and Presiding Officer.

The Toastmaster presented President F. O. Clements who delivered the annual Presidential Address entitled, "Research and the American Society for

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[1] The returns of the letter ballot on these recommendations were favorable and are given in detail on page 463.

[2] The report was submitted to letter ballot of the committee, which consists of 59 members; 32 members returned their ballots of whom 22 have voted affirmatively and none negatively.

Testing Materials." A continual search for new knowledge was asserted by President Clements to be the objective of the Society. He emphasized the need of increasing Society research activities on materials problems and the allied testing field. In pointing out that extensive standardization work may be dangerous in that it may lead to mental standardization he said: "The antidote and remedy for such a danger is a continual search for new knowledge or research in the field of materials."

The Toastmaster then recognized Mr. J. C. Pearson, member of the Committee on Award of the Charles B. Dudley Medal, who presented Mr. C. A. Menzel as the recipient of the 1932 award of the Dudley medal for his paper on "Tests of the Fire Resistance and Stability of Walls of Concrete Masonry Units," presented before the 1931 annual meeting of the Society and considered by the committee as a paper of outstanding merit constituting an original contribution on research in materials.

On behalf of and as the representative of the Society, President Clements then made the sixth award of the Charles B. Dudley Medal to Mr. Menzel.

In accepting the medal, Mr. Menzel expressed his appreciation of the award as follows:

> "Mr. President, Members of the Society, and Guests: I sincerely appreciate the honor and recognition that the award of this medal conveys, not only from a personal standpoint but also because it gives recognition to an investigation in the important field of fire resistive construction.
>
> "In receiving this medal, I wish to acknowledge my appreciation and gratitude to the various individuals and groups who either directly or indirectly made this investigation possible and to those who aided in the planning and carrying out of the test program.
>
> "The art of testing the performance of walls, floors, columns and other building members when exposed to fire has been gradually developed during the past 30 years. Committee C-5 of this Society has been an important factor in this development in that it has afforded an opportunity for the systematic interchange of the ideas and experience of those interested in the advancement of this art and its practical application. The specifications for fire tests of building materials and construction that were formulated by this committee in 1926 have received national recognition and were used with but slight modification in this investigation.
>
> "There is an increasing need for more definite knowledge of the fire resistive properties of all building materials in order that they be more effectively used in various assemblies to provide the desired resistance to fire at a reasonable cost. With further information in this field it will be possible to design building members to meet definite requirements as to fire resistance with a precision approaching that obtained in the usual design for strength.
>
> "It is very gratifying indeed to have contributed to this end and to have received this signal honor. Mr. President, I thank you."

The Toastmaster then recognized L. W. Olson, chairman of the Committee of Tellers, who reported the results of the letter ballot on election of officers. Of the 835 ballots cast, the results were as follows:

For President, to serve for one year: Cloyd M. Chapman, 834 votes.
For Vice-President, to serve for two years: W. H. Bassett, 835 votes.

For Members of Executive Committee, to serve for two years:

H. A. Gardner, 835 votes.
J. O. Leech, 833 votes.
J. T. MacKenzie, 835 votes.
J. C. Ramage, 835 votes.
H. S. Vassar, 835 votes.

The Toastmaster then presented the President-Elect and Vice-President-Elect, both of whom responded and expressed sincere appreciation of the honor of their election. The Toastmaster also presented T. R. Lawson, Vice-President, who had been appointed by the Executive Committee to fill the unexpired term of S. T. Wagner, deceased. In responding Mr. Lawson paid tribute to Mr. Wagner as one well-beloved by all members of the Society. The Toastmaster then presented the newly elected members of the Executive Committee.

The dinner meeting then adjourned and was followed by an informal dance and smoker.

EIGHTH SESSION—THURSDAY, JUNE 23, 9.30 A. M.

Cast Iron, Effect of Temperature on Metals

(Held Simultaneously with Ninth Session)

Mr. R. A. Bull in the chair.

The report of Committee A-7 on Malleable Iron Castings was presented by E. K. Smith. The proposed Tentative Specifications for Malleable Iron Castings were accepted for publication as tentative. On motion, the report was adopted.

The report of Committee A-3 on Cast Iron was presented by the chairman, Hyman Bornstein. The proposed Tentative Specifications for Cast-Iron Culvert Pipe were accepted for publication as tentative. The proposed revision of the Standard Specifications for Gray-Iron Castings (A 48 – 29) and for High-Test Gray-Iron Castings (A 88 – 31) in the form of proposed Tentative Specifications for Gray-Iron Castings was accepted for publication as tentative with the following changes in the proposed tentative specifications, which revisions were approved subject to favorable letter ballot[1] of Committee A-3:

Section 3.—Omit the deflection requirements from the specifications as preprinted and substitute the following as a new Paragraph (*b*) relettering the present Paragraph (*b*) as Paragraph (*c*):

> "(*b*) By agreement between the manufacturer and purchaser, deflection values in the transverse test may be specified."

Section 5.—In the table following Paragraph (*a*) of this section change the dimensions of the controlling section of castings from "0.75 to 1.25 in." to read "0.76 to 1.10 in."; also change "1.25 to 2.00 in." to read "1.11 to 2.00 in."

Table I.—Change the correction factors corresponding to various diameters of the 0.875-in. diameter bar by substituting the following diameters and correction factors for those in the first two columns of Table I of the specifications as preprinted:

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[1] The specifications as revised were submitted to letter ballot of the committee which consists of 99 members; 52 members returned their ballots of whom 46 have voted affirmatively and none negatively.

Diameter of Test Bars, in.	Correction Factor	Diameter of Test Bars, in.	Correction Factor
0.825	0.838	0.875	1.000
0.830	0.853	0.880	1.017
0.835	0.869	0.885	1.034
0.840	0.885	0.890	1.051
0.845	0.900	0.895	1.069
0.850	0.916	0.900	1.087
0.855	0.933	0.905	1.106
0.860	0.949	0.910	1.125
0.865	0.966	0.915	1.143
0.870	0.983	0.920	1.162
		0.925	1.181

On motion, the report as amended was adopted.

A paper entitled "Mechanism of Deformations in Gray Iron," by J. W. Bolton, was presented by the author.

An informal progress report of the Sectional Committee on Specifications for Cast-Iron Pipe and Special Castings was presented by the Assistant Secretary.

A paper entitled "Influence of Recrystallization Temperature and Grain Size on the Creep Characteristics of Non-Ferrous Alloys," by C. L. Clark and A. E. White, was presented by Mr. Clark.

The report of the Joint Research Committee on Effect of Temperature on the Properties of Metals was presented by the chairman, H. J. French. In presenting the report Mr. French called on H. W. Gillett to present from manuscript a paper by himself and H. C. Cross entitled "Variations and Variables in Cooperative Creep Testing of a Chromium-Molybdenum Steel." Mr. French also called on P. G. McVetty to present the report on Correlation of Tension, Creep and Fatigue Tests of 0.17 per cent Carbon Steel at Elevated Temperatures, on N. L. Mochel to present from manuscript a report of Subcommittee M of Committee III on "Structural Stability of 18 per cent Chromium, 8 per cent Nickel, Stainless Steels at Elevated Temperatures in the Absence of Stress," and on H. W. Gillett to describe the impact investigations on stainless steels.

A paper entitled "Thermal Effects of Elastic and Plastic Deformation," by M. F. Sayre, was presented by the author.

The meeting then adjourned till 8 p. m.

Ninth Session—Thursday, June 23, 9.30 a. m.

Timber, Coal, Paving and Waterproofing Materials

(Held Simultaneously with Eighth Session)

Past-President K. G. Mackenzie in the chair.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. In presenting the report Mr. von Schrenk called on S. R. Church to present the report of Subcommittee VI on Timber Preservatives. The proposed Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tar) were accepted for publication as tentative. On motion, the report was adopted.

The report of Committee C-5 on Fire Tests of Materials and Construction was presented by A. R. Small and on motion was adopted.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The proposed Tentative Method of Sampling Coke for Analysis was accepted for publication as tentative. The proposed Tentative Method of Sampling Coal by Ball-Mill Method was accepted for publication as tentative to be subsequently incorporated in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30). On motion, the report was adopted.

The report of the Sectional Committee on Classification of Coals was presented by the chairman, A. C. Fieldner, and on motion was accepted for publication.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by J. M. Weiss and on motion was adopted.

A paper entitled "An Apparatus and Method for Measuring the Consistency of Roofing Putties and Fibrous Roof Coatings," by G. W. Clarvoe was presented by the author.

The report of Committee D-4 was presented by the chairman, P. J. Freeman. The proposed Tentative Methods of Chemical Analysis of Calcium Chloride were accepted for publication as tentative. The proposed revision of the Tentative Method of Test for Consistency of Portland-Cement Concrete (D 138 – 26 T) was accepted, the method as revised being continued as tentative.

The committee recommended the advancement to standard of the tentative revision of the definitions of the terms bitumens, asphalts, flux, tars and pitches in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18). After discussion of the terms asphalts, tars and pitches, the recommendation was on motion approved for reference to letter ballot of the Society for adoption. On motion, the report was adopted.

A paper entitled "The Volatile Combustible Matter of Coal-Tar Pitch," by J. M. Weiss, was presented by the author.

The meeting then adjourned till 8 p. m.

TENTH SESSION—THURSDAY, JUNE 23, 8 P. M.

On Corrosion and Fatigue of Metals

Vice-President T. R. Lawson in the chair.

The report of Committee A-5 was presented by the vice-chairman, H. E. Smith. The proposed revisions of the Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 30), for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 30), for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 30), for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 30), for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 30) and for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (A 122 – 30) were accepted for publication as tentative. The withdrawal of the Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized Before Weaving (A 118 – 30 T) was approved.

The Recommendations for Safeguarding Against Embrittlement of Hot-Galvanized Structural Steel Products and Procedure for Detecting Embrittlement, published in the preprinted report as a proposed guide, were presented with revisions as a Tentative Recommended Practice and accepted subject to a favorable letter ballot[1] of Committee A-5.

In presenting the report Mr. Smith called upon F. N. Speller to describe the investigations of Subcommittee III on Total Immersion Tests, on R. F. Passano to present the report of Subcommittee VIII on Field Tests of Metallic Coatings and on V. F. Hammel for the report of Subcommittee X on Embrittlement Investigation.

Attention was called to a number of changes in the report as preprinted and on motion the report as amended was adopted subject to a favorable letter ballot[2] of Committee A-5.

A paper entitled "Embrittlement of Hot-Galvanized Structural Steel," by Samuel Epstein, was presented from manuscript by the author.

The report of the Sectional Committee on Zinc Coating of Iron and Steel was presented by the vice-chairman, C. S. Trewin, and on motion was accepted for publication.

At this point the program was interrupted for the presentation of prizes for the sixteenth annual golf tournament. The winners were announced and the prizes awarded by A. R. Small on behalf of the Entertainment Committee. The A.S.T.M. Championship Golf Cup for low score was won for the fourth time by H. G. Farmer. Other prize winners in the tournament were: E. D. Boyer, J. G. Bragg, W. B. Price, D. W. Mulford, J. H. Chubb and J. J. Crowe.

The following papers on corrosion and fatigue of metals were then presented:

"Controlled Data from an Immersion Test," by R. F. Passano—presented by the author.

"Some Factors Affecting the Preece Test for Zinc Coatings," by H. H. Walkup and E. C. Groesbeck—presented by H. S. Rawdon.

"Effect of Zinc Coatings on the Endurance Properties of Steel," by W. H. Swanger and R. D. France—presented by Mr. Swanger.

"Fatigue of Shafts Having Keyways," by R. E. Peterson—presented by the author.

"Fatigue Failure Under Repeated Compression," by H. R. Thomas and J. G. Lowther—presented by H. F. Moore.

The report of the Research Committee on Fatigue of Metals was presented by the chairman, H. F. Moore, and on motion was accepted for publication.

The meeting then adjourned till the following morning.

ELEVENTH SESSION—FRIDAY, JUNE 24, 9.30 A. M.

Cement, Lime, Gypsum, Ceramics

(Held Simultaneously with Twelfth Session)

Vice-President Cloyd M. Chapman in the chair.

The report of Committee C-1 on Cement was presented by the chairman, P. H. Bates. The revisions proposed for immediate adoption in the Standard

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[1] The recommended practice was submitted to letter ballot of the committee which consists of 121 members; 83 members returned their ballots of whom 61 have voted affirmatively and none negatively.

[2] The report as amended was submitted to letter ballot of the committee which consists of 121 members; 83 members returned their ballots of whom 72 have voted affirmatively and 1 negatively.

Methods of Testing Cement (C 77 – 30) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The withdrawal of the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 – 16 T) was approved. On motion, the report was adopted.

A paper entitled "Measurement of Particle Size with an Accurate Air Analyzer: The Fineness and Particle Size Distribution of Portland Cement," by P. S. Roller was presented by the author.

The report of Committee C-11 on Gypsum was presented by L. S. Wells. The proposed revisions of the Standard Specifications for Gypsum Partition Tile or Block (C 52 – 27) and Methods of Testing Gypsum and Gypsum Products (C 26 – 30) were accepted for publication as tentative. On motion, the report was adopted.

The report of Committee C-7 on Lime was presented by the vice-chairman, E. E. Eakins, and on motion was adopted.

The report of Committee C-4 on Clay Pipe was presented by the chairman, G. T. Hammond. The proposed revision of the Standard Specifications for Clay Sewer Pipe (C 13 – 24) was accepted for publication as tentative. On motion, the report was adopted.

An informal report on the organization of Committee C-12 on Mortars for Unit Masonry was presented by the secretary, F. Leo Smith.

The report of Committee C-6 on Drain Tile was presented by the assistant secretary, D. A. Abrams, and on motion was adopted.

The report of Committee C-8 on Refractories was presented by the Assistant Secretary. The proposed Tentative Method of Test for Particle Size of Ground Refractory Materials was accepted for publication as tentative. The proposed revision of the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31) was accepted for publication as tentative. The approval by the committee of the modulus of rupture or flexure strength test described in the Standard Methods of Testing Brick (C 67 – 31), developed under the jurisdiction of Committee C-3 on Brick, for use in testing refractories was reported. The advancement to standard of the tentative revisions of the Standard Methods of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 20) and in Section 2 of the Test for Softening Point of Fire-Clay Brick (C 24 – 31) was referred to the Executive Committee with power. On motion, the report was adopted subject to a favorable letter ballot[1] of Committee C-8.

The meeting then adjourned till 2 p. m.

TWELFTH SESSION—FRIDAY, JUNE 24, 9.30 A. M.

Non-Ferrous Metals

(Held Simultaneously with Eleventh Session)

Mr. W. H. Bassett in the chair.

The report of Committee B-1 on Copper Wire was presented by W. H. Bassett. The proposed Tentative Specifications for Hard-Drawn Copper Transmission Cable were accepted for publication as tentative. The revisions proposed for immediate adoption in the Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 30), and for Bronze Trolley

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[1] The report was submitted to letter ballot of the committee which consists of 32 members; 32 members returned their ballots of whom 28 have voted affirmatively and 1 negatively.

Wire (B 9 - 30), were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. On motion, the report was adopted.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented by the chairman, T. S. Fuller. In presenting the report Mr. Fuller called on W. H. Finkeldey to present the report of Subcommittee VI on Atmospheric Corrosion, on R. J. McKay to present the report of Subcommittee VII on Liquid Corrosion, and on C. L. Hippensteel to present the report of Subcommittee VIII on Galvanic and Electrolytic Corrosion. On motion, the report was adopted.

The report of Committee D-14 on Screen Wire Cloth was presented from manuscript by the secretary, W. H. Bassett, and on motion was adopted.

The report of Committee B-4 on Electrical-Heating, Electrical-Resistant and Electric-Furnace Alloys was presented by the chair and on motion was adopted.

A paper entitled "Effect of Cold Working on the Izod Notched-Bar Impact Value of Monel Metal," by N. B. Pilling was presented by T. J. Wood.

The report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, was presented by the chairman, C. H. Mathewson. The proposed Tentative Specifications for Copper Water Tube were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11 - 18), for Copper Bars for Locomotive Staybolts (B 12 - 21), for Seamless Copper Boiler Tubes (B 13 - 18), for Copper Pipe, Standard Sizes (B 42 - 24), for Brass Pipe, Standard Sizes (B 43 - 24), and for Sheet High Brass (B 36 - 27) were accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 - 31 T) and for Seamless Copper Tubing, Bright Annealed (B 68 - 30 T) were accepted, the specifications as revised being continued as tentative. The proposed revision of the Tentative Specifications for Sand Castings of the Alloy: Copper, 80 per cent; Tin, 10 per cent; Lead, 10 per cent (B 74 - 28 T) appearing in the report as preprinted was withdrawn by the committee. The withdrawal of the Standard Specifications for Bronze Bearing Metal in Ingot Form (B 31 - 21) was approved. On motion, the report as amended was adopted.

A paper entitled "Factors Affecting the Physical Properties of Cast Red Brass (85 Cu, 5 Zn, 5 Sn, 5 Pb)," by H. B. Gardner and C. M. Saeger, Jr., was presented by Mr. Gardner.

The meeting then adjourned till 2 p. m.

THIRTEENTH SESSION—FRIDAY, JUNE 24, 2 P. M.

Non-Ferrous Metals, Metallography

(Held Simultaneously with Fourteenth Session; Continued from Twelfth Session)

Mr. H. W. Gillett in the chair.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the vice-chairman, W. H. Bassett, and on motion was adopted.

An informal progress report of the Sectional Committee on Zinc and Zinc Ores was presented by the chairman, W. H. Bassett.

A paper entitled "Mechanical Properties of White-Metal Bearing Alloys at Different Temperatures," by H. K. Herschman and J. L. Basil, was presented by Mr. Herschman.

The report of Committee B-6 on Die-Cast Metals and Alloys was presented by the chairman, H. A. Anderson, and on motion was adopted.

The report of Committee B-7 on Light Metals and Alloys, Cast and Wrought, was presented by the secretary, J. A. Gann. The proposed Tentative Specifications for Magnesium-Base Alloy Sheet and for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) were accepted for publication as tentative. The committee also presented a revision of the proposed Tentative Specifications for Aluminum Alloy Wire, Rods and Bars, appearing in the report as preprinted. The revised specifications entitled, "Tentative Specifications for Aluminum-Copper-Magnesium-Manganese Alloy Bars, Rods and Shapes," were accepted for publication as tentative. On motion, the report as amended was adopted.

The report of Committee E-4 on Metallography was presented by the chairman, C. H. Davis, and on motion was adopted.

A paper entitled "Method of Preparation of Lead and Lead Alloy Cable Sheath for Microscopic Examination," by W. H. Bassett, Jr., and C. J. Snyder, was presented by Mr. Snyder.

The meeting then adjourned to the Fourteenth Session where the annual meeting was formally closed.

FOURTEENTH SESSION—FRIDAY, JUNE 24, 2 P. M.

Concrete, Building Stones

(*Held Simultaneously with Thirteenth Session*)

Mr. F. E. Richart in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, Cloyd M. Chapman. The proposed revisions of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 - 31), of Making Compression Tests of Concrete (C 39 - 27), of Test for Organic Impurities in Sands for Concrete (C 40 - 27), and of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24) were accepted for publication as tentative. The proposed revisions of the Tentative Methods of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar (C 87 - 31 T) and of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (C 89 - 31 T), were accepted, the methods as revised being continued as tentative. The proposed revision of the Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 - 31 T) was accepted with changes providing for material passing the No. 50 sieve and retained on the No. 100 sieve, the proposed revision as preprinted having provided only for material down to the No. 50 sieve size, the methods as revised to be continued as tentative.

In presenting the report Mr. Chapman called on C. H. Scholer to describe the proposed method of testing concrete and concrete aggregates by freezing and thawing, submitted by Mr. Scholer and A. E. Stoddard and published as information. On motion, the report as amended was adopted.

An informal report of the Society's representatives on the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete was presented by P. H. Bates.

The following papers were then presented:

"Tests on Consistency and Strength of Concrete Having Constant Water Content," by Inge Lyse—presented by the author.

"Volume Changes of an Early-Strength Concrete," by E. R. Dawley—presented by C. H. Scholer.

"The Electric Strain Meter and Its Use in Measuring Internal Strains," by R. E. Davis and R. W. Carlson—presented by F. R. McMillan.

"Relative Merit of Various Materials Used in Capping Concrete Specimens," by M. V. Nardiello—presented by title.

The report of Committee D-18 on Natural Building Stones was presented from manuscript by the secretary, H. S. Brightly, and on motion was adopted.

President-Elect Cloyd M. Chapman then assumed the chair. A vote of thanks was on motion, extended to the Entertainment Committee, and to the Ladies Entertainment Committee. A vote of appreciation to the officers and members of the Society's Headquarters Staff was also adopted in recognition of their diligent and untiring labors during the year.

There being no further business, President-Elect Chapman declared the Thirty-fifth Annual Meeting adjourned *sine die.*

RESEARCH AND THE AMERICAN SOCIETY FOR TESTING MATERIALS

ANNUAL ADDRESS BY THE PRESIDENT

F. O. CLEMENTS

JUNE 22, 1932

Dr. Charles B. Dudley, tireless searcher for the truth; endowed with keen powers of observation; an insatiable investigator; one of the Founders of our Society and its first President, was more than a friend of mine. To have started my own career in his laboratory was indeed a privilege that has meant much to me in my subsequent professional activities. His photograph hangs in my office close to my desk. The early members of this Society revered and loved him. His Presidential Addresses are looked upon as classics. Never did I imagine, that a quarter of a century later, I should be permitted to serve his Society as President. I marvel constantly at the type of men who comprise the membership of the A.S.T.M. It is a privilege to have had such an intimate association with the personnel and problems of our Society. During my term of office as President, I have been visiting various committees in session, trying to get an overall conception of present-day activities as well as a vision of what lies ahead. When I first heard of the A.S.T.M. from the lips of Doctor Dudley, there were practically only two major activities in our country—agriculture and railroading. The steel industry, while a lusty infant, was a pigmy compared to present-day proportions. So, for many years, the activities of the American Society for Testing Materials were properly confined to steel and various other railroad materials. The Pennsylvania Railroad laboratory was also one of the early pioneers that finally developed into the great research laboratories of the present time.

I can see very little difference between Doctor Dudley's objective and the one that actuates our modern research laboratories: namely, a continual search for new knowledge.

And that must be our objective in the A.S.T.M.—*a continual search for new knowledge*. Standardization work carries a great peril, which is mental in character. Let us standardize materials and processes, but be very careful not to standardize our minds. For this element of peril surely does exist. Standardization of ideas means no progress. Standardization must always go forward without building fences to prevent developments or block future progress. Standardization must be the servant and not the master. These admonitions are axiomatic ones that might properly grace the walls of our Society Headquarters. The antidote and remedy for such a danger is "A continual search for new knowledge" or "Research in the field of materials." This is the subject I wish to discuss this evening. Prior to so doing, I should like to briefly outline some of the happenings of the past year and give an account of my stewardship.

Our membership, for the first time in years, has failed to show growth—this, despite the herculean efforts of our Membership Committee. As in the case of most engineering organizations, the difficult business situation has finally broken our continuous growth in membership.

The comparison is as follows: December 31, 1930—4417, December 31, 1931—4332; on March 31, 1932, we had a total membership of 4182. We need several hundred new members, for our ability to do useful work depends on both membership dues and publication sales. We have asked the Old Guard to come to the rescue, the men who have valiantly worked and fought for our Society in every emergency.

Death has invaded our ranks again and again. The toll has been heavy, including two members of the Executive Committee, Vice-President Samuel Tobias Wagner and Mr. H. N. Van Deusen, Chairman of the Membership Committee. In addition, I cannot refrain from mentioning the death of our very illustrious member, Thomas A. Edison.

Our publicity is in strong hands and the results have been particularly pleasing. All of this splendid effort will count greatly, later on.

The third Regional Meeting devoted to a Symposium on Rubber, held in Cleveland, March 9, 1932, like its predecessors, was an outstanding success. These various symposiums bring together producer and consumer in a specific field of endeavor and result in a compilation of useful information of great value to industry.

A number of District Meetings have been held during the past winter. The New York District Committee, in particular, staged three outstanding events. I am particularly gratified with these various meetings for in many instances they represented cooperative enterprises with other national engineering societies. The Detroit Meeting was a joint one, fostered by the American Society for Testing Materials, the Society of Automotive Engineers and the American Society for Steel Treating. The Chicago Meeting had as affiliate, the Western Society of Engineers. One of my main objectives has been the cementing of finer and better relationships with our sister societies. Marked advance in such relationships has resulted this particular year. Duplication of effort and the development of conflicting specifications are undesirable, for they lead to confusion. We stand ready to be of service wherever possible. We should work with folks and not for folks.

Let me urge the formation of other divisional groups, whose duty it will be to foster at least one outstanding meeting each year. Many desirable by-products come from such meetings—particularly from the publicity standpoint and the further cementing of good fellowship.

A number of our Executive Committee members have established a half dozen student memberships for their own Alma Mater—such memberships to be granted for outstanding scholastic achievement in some particular engineering subject. This is a fine feature, worthy of emulation, by others.

We have lived this year within our income. This has been accomplished by close scrutiny of all operations involving the expenditure of money or effort. Furthermore, the effectiveness of our work has not been curtailed in the slightest degree by our adherence to sound economic principles. The official staff are to be complimented for their fine cooperative spirit in these days of stress.

Our group of men, comprising the membership of the A.S.T.M., have had quite a share in the ever increasing tempo of scientific research as applied to industry. The art of applying the discoveries of science has made marvellous strides, but the human relationships involved lag behind. Political, social and economic relations have shown signs of strain. Every nation is seeking for values which endure and they begin to see that real engineering is the use of the forces and resources of Nature for the benefit of all mankind. More and more frequently there appear in our present-day technical literature suggestions that we should include cultural subjects in our engineering curriculum. These suggestions are usually made by our best engineers, and for that reason they carry weight.

Dean Herman Schneider of the University of Cincinnati is responsible for this very interesting statement:

> "Believe it or not, nine out of every ten young men coming to college are idealists, not materialists. They don't like to admit it; they fumble and shift

> about at first when you confront them with it. But at bottom they have a sort of chivalry about being of service, especially the engineers; and they rise much more spontaneously than older and seemingly wiser people do, to the idea that a bridge is not an end in itself—that it is a highway to greater inlets and outlets for the human mind; they see that the printing press is such a highway too, and the radio, and every other thing that makes for the difference between America and say China, in health, in educational opportunities, in freedom to move about—principally upward. They respond to the idea that the success of one's career on earth is measured at the time one passes on to the next existence and that the measuring is done in terms of the intangible things taken along, not the tangible gain left behind; by what is given, not by what is gotten. They grasp the philosophy that the only durable things are the intangible ones—not the bridge but what the bridge stands for."

As I visit with you boys, I usually find much discussion as to what's wrong with our present-day civilization. Your heart is in the right place, for you are much concerned about the welfare of others.

Dr. Frank B. Jewett of the Bell Telephone Laboratories makes this interesting statement:

> "In the past, our technical societies have been in large measure places of meeting where technicians could gather together for a general interchange of ideas, for a discussion of technical problems and for the taking of whatever group action seemed advantageous for the advancement of our profession. Possibly in the years ahead our engineering societies, either through modification of their present organization or in their association one with another in such things as the American Engineering Council, will find it expedient and necessary to equip themselves in better fashion to play the part which Society has a right to demand of us, its experts in this particular field, in bringing to play on the problems which will confront our people the general concensus of understanding which we alone possess in greatest measure. Engineers have not taken the same part in the evolution of Society that they must take in the future."

He suggests that the technical society must equip itself to play its part in directing the understanding of its members on the technical phases of the problems of the world.

Others say: "The increase in efficiency of the industrial machine must be a servant of mankind. We cannot bring truth, goodness and beauty appropriate to our age into the common life without correcting our material ailments." "The responsibility of the engineer for the present social order is generally admitted. The object of each project should contribute tangible advances to human welfare." Still again—"More engineers must be leaders of industry, if a scientific civilization is to survive."

Remember, the steam engine was of little value until man, the creator, provided a governor. This control feature was the work of an engineer.

I interpret these various statements to mean that we, as a society of thinking men, have a duty to perform. Perhaps subjects that have to do with the future welfare of our country should receive attention by us. Are we measuring up to our responsibilities?

These opinions all sum up in the dictum: Engineers must play a larger part by furnishing in the future new leadership. Particularly do these suggestions apply to us, for there is no other organization quite like the A.S.T.M. We are a cross-section of all the national engineering societies, which means that our cooperative influence should be extremely effective.

Every month brings new appliances, new materials, new methods. Our Society helps dramatize them and makes them useful in service. This is too prosaic a task to evoke much interest from the general public. Our work is not spectacular. Gradually, over a period of years, our standardization activities have brought us to the realization that a continual search for new knowledge is increasingly necessary.

I have mentioned, heretofore, that standardization should be a system of classification and should not restrict our future advances. Furthermore, standardization requires frequent revisions so as not to interfere with progress. A recent development of great import has to do with the extreme-pressure class of lubricants. So little is known of the underlying principles which make these new products of value that interesting policy questions arise. Much research in both the automotive and petroleum industry is under way.

Some type of classification is needed to help clarify our present-day conceptions of this very important class of lubricants. However, the phenomenon of lubrication is still in rather primitive stages, as far even as our theories and beliefs are concerned. It is a subject of great practical importance and of intense scientific interest. Extreme-pressure lubrication begins where fluid film conceptions cease to exist. Seemingly, a film of metal is deposited by electrolytic action, a film submicroscopically thick, which serves as an extreme pressure lubricant. This development is of a startling nature and promises to open up a marvellously interesting field for future investigations. Much research remains to be done and much service testing is necessary to correlate the results in the field with suitable laboratory testing equipment. This is such a typical problem that seemingly further discussion is in order. Great care must be exercised in interpreting results obtained with any laboratory machine or method. The lubricants are not made to lubricate testing machines but rather to lubricate gears and bearings in actual service; and only actual data that can be related to service must be used. So the development program logically follows the lines of least resistance: First, adequate service data proving quantitatively the lubricating quality of all the types of extreme-pressure lubricants now known; second, the development of a suitable laboratory testing machine, one that will simulate service conditions and separate worthy products from worthless ones.

These two procedures will unquestionably immediately stimulate research for other and better types of extreme-pressure lubricants. A tentative specification must soon originate to clarify existing knowledge, so that the consumer may state his needs in intelligent terminology. For unquestionably, extreme-pressure lubricants of different strengths and potency will be needed to satisfy the varying service demands. In a new subject of such magnitude, quick changes will be necessary in revising specifications as knowledge increases. Ultimately the best products will win out and find wide distribution the country over. Then, and then only, will some sort of stabilization be reached.

This work, at present, is in the hands of a joint committee of the Society of Automotive Engineers, the American Petroleum Institute and the Bureau of Standards. Ultimately, when complete standardization is required, our Society may be able to be of service. At any rate this development, in time, will be subject matter worthy of careful consideration by our Society. Perhaps a Symposium on Extreme-Pressure Lubricants will soon be in order.

It would be quite impossible to give even a short review of the original work of a research character to be found in our literature. Some fifty research projects are under active consideration. Many of them are carried on cooperatively with other national engineering societies.

As I see it, it would not be wise for our organization to undertake research on far-reaching problems leading to new fundamental knowledge. I mean by the term fundamental, the acquisition of new knowledge, dissociated from any idea of practical utilization. Our organization and research funds would not begin to meet the requirements. We must, of necessity, apply our research effort strictly to materials and the allied testing field.

A typical illustration is the Joint Research Committee of the American Society of Mechanical Engineers and the American Society for Testing Materials, occupied in studying the effect of temperature on the properties of metals. Two active projects are under way at present at the University of Illinois and the Battelle Memorial Institute. A three-year Research Program calls for some $20,000—the money involved largely supplied by interested industries and research foundations.

The Society's research work in "fatigue" of metals is of a somewhat different character. Here we abstract the principal published data of the world on this particular subject—thereby presenting present-day knowledge which serves to stimulate further studies.

In the field of concrete and concrete aggregates, our Society is carrying on a number of important research projects with noteworthy and worthwhile results. Time will not permit details of other important work.

I like to think of our accumulated knowledge in the terms of a high mountain. The higher we climb, the wider the horizon and the farther we can see.

The new developments of today become the standards of tomorrow. So we must be active in gathering and disseminating new knowledge, lest we stand still.

It is the society that takes the longest view and realizes most clearly the value of deepening knowledge of fundamental problems, that will reap in the future the fruits of great achievements.

Mr. C. F. Kettering, one of our own members, recently published a popular article in *The Saturday Evening Post* entitled: "The World Isn't Finished." Let no one doubt the ability of American business to stage a comeback. Most of the things that have hindered our vision have been removed. We must and will correct some of our glaring faults as a nation. A few years from now we will be engaged on projects not even thought of now. The imagination of the engineer will be needed to harness modern mechanism to higher ideals, resulting in expanded human life. Various engineers and scientists present widely different future needs. Frank Lloyd Wright says: "We must choose between the automobile and the vertical city." Dr. Bakeland mentions better government; L. W. Wallace and Arthur D. Little call for better homes; Lee de Forrest thinks we will be active in capturing the heat under ground; Elihu Thompson and Dr. Kintner talk about harnessing the sun's radiant energy; Dr. Northrup, perfect television; Dr. Jewett thinks we need more sanity, more intelligence, more restraint; Dr. M. I. Pupin, a new democracy.

Floyd W. Parsons states:

> "The next ten-year period will see marked advances in: frozen foods, air conditioning of homes, electron tube developments of far-reaching importance, cheap magnesium, pipe-line extensions for conveyance of oil, gas, and perhaps even coal, the teletype development, vast improvements in radio and radio broadcasting, through highways, safer flying, synthetic products innumerable, more effective sources of power. Electrification of railroads will go along at

an unprecedented pace, for American railroads are not going out of business. The radio, the telephone and the automobile will continue to change the future of our civilization. Every new discovery, every fresh invention is merely a starting point for a new industry. Life will be carried to new and higher planes. Our metal and mineral industries still have a great future; new alloys are coming fast—the surface only has been scratched. Veritable miracles will be performed by the chemist and the metallurgist. We are not approaching a saturation point in the fields of power and heat. There will be new things everywhere."

You say, what about the machine age and unemployment? When I was born, one person in every twenty-three was employed industrially. In 1925, the population had grown five fold and one person out of every eleven was employed in industry. Improvement and invention do cause need of readjustment but they leave two opportunities for employment where one existed before.

People and materials are the only two things we can experiment with and unless we continue to experiment, we shall fail to discover those things which will have a direct bearing on our industrial future. Continued prosperity is based on new discoveries and achievements, the result of research and invention. Research and education can never be overdone, for they are both non-consumable activities. And furthermore they greatly tend to advance civilization. We neglect them at our peril.

We must be dissatisfied with things as they are, to make progress. The most important reason for a new thing to replace the old would be for it to perform a service which was not previously possible. The telegraph and telephone made rapid transmission of messages possible, where it was impossible before.

So it behooves our Society to pin its faith to the continual search for and the dissemination of new knowledge.

Mr. Mackenzie in his Presidential Address of last year called specific attention to our Research Fund of $8387.85 which, by the way, has seen no increase this year. The income from this fund is the only money of our own that is directly available for support of our research effort; it must be, and fortunately it is, supplemented by funds and services contributed by industry for specific projects. But, how pitifully small is this income and how stupendous is the task! Mr. Mackenzie further said: "There is work to be done; we should do it." The time to endow research is when we have plenty of money. So let me suggest, when conditions rectify, that we greatly augment the principal of this account. It would not be proper to be satisfied with this infinitely insignificant research fund, nor should these remarks of mine close without setting an objective worthy of the best that is in us. We should possess a research fund of at least $500,000. This is a bold challenge, rather impossible under present-day business conditions but perfectly possible in the years to come. My suggestion would be to organize a specific committee of the Society to formulate methods of procedure and to begin an educational campaign amongst our own membership, perhaps with a lesser amount as the initial objective. Let us not forget that research presents a bewildering array of possible fields of exploration. There is always a tendency to waste such funds by engaging in too many projects of minor importance. The futility and wastefulness of such a policy has been demonstrated again and again. Such pitfalls we must avoid. This warning may be unjustifiable just now. In time, its significance will be paramount in importance. We will never possess such a sum of useful money unless we set an objective. Why not begin now and plan effectively for the days that lie ahead? An active research fund insures our future. Let me suggest the gift of stock or money, the return thereon to come to you as an annuity as long as you live, the principal at death to go to the A.S.T.M. Research Fund. Or put it in your will; no money can be invested more usefully; it will work long and effectively after our day is done. Bequests should be left without special designation but for use as changing circumstances may require.

Great things lie ahead for this Society. Much work remains to be done. This Society is a Service organization working for others. Remember always, the law of the universe is Service: that without Service perishes; the environment of Service is joy; the atmosphere of Service is peace; the miracle of Service is that one is never defeated. In Service nothing is lost.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee desires first to refer briefly to the effect of present-day conditions upon the Society's activities. The year 1931 was an outstandingly successful one for the Society in every way, except for the fact that a small net loss in membership occurred for the first time in its history. However, the corresponding decrease in income from dues was largely offset by increase in receipts from sales of publications and from other sources, so that with all publication and other activities completed, the year showed a favorable balance of slightly over $5000. Beginning with the present year, however, resignations from membership became relatively heavy and there was also an increase in the number of members delinquent in payment of past and current dues. As a result there is recorded in this report a net loss in membership for the year ending June 1, 1932, of about 365, or approximately 8½ per cent of the membership a year ago. This loss, while quite considerable and materially reducing the income of the Society, is still not unduly large in view of the difficult economic and industrial conditions through which the entire country is passing. Until very recently receipts from sales of publications have not been affected, but some falling off has been noted in the past two months.

So far there has been no curtailment of the Society's work. It is inevitable that the Society and its activities should be affected to some degree by conditions through which we are passing, and it will be evident from the references to finances subsequently in this report that the Executive Committee is considering these matters most carefully. Every effort will be made so to manage and direct the operations of the Society that all essential activities and services rendered to the members will be continued to the fullest extent possible, in recognition of the fact that undoubtedly the research and standardization activities of the Society are of undiminished value to the industries of the country in these times of economic stress.

The Executive Committee offers the following report of general Society activities for the year ending with this annual meeting:

Membership:

The membership of the Society on June 1, 1932, was 4163. Statistics showing gains and losses in the various classes of membership are as follows:

Class of Members	Membership		Losses				Additions		Total		
	June 1, 1931	June 1, 1932	Resignations	Dropped	Death	Transfer	Transfer	Election	Loss	Gain	Decrease
Honorary	4	4	...	...	..	..	..	...	...	...	...
Life or Perpetuity	11	11	...	...	..	..	..	...	...	...	...
Sustaining	....	5	...	...	..	..	5	...	...	5	5[a]
Company, Firm, etc	1124	1026	122	...	..	11	2	33	133	35	98
Individual, etc	3102	3037	245	4	25	2	22	189	276	211	65
Junior	86	80	10	...	..	16	..	20	26	20	6
Total	4327	4163[b]	377	4	25	29	29	242	435	271	164
Student	211	134	25	107	..	10	..	65	142	65	77

[a] Increase.

[b] This includes 204 members delinquent for 1931 dues who would normally have been dropped in April but are by action of the Executive Committee carried this year until July.

These figures reflect very directly one of the effects upon the Society of the prevalent industrial conditions. Not only is the number of resignations, 377, much greater than in any preceding comparable period (the corresponding figure reported a year ago was 229), but at the same time the number of new members elected to the Society, 242, is much smaller than for many years, comparing with 362 reported a year ago and 430 two years ago. In its desire to meet in so far as possible the undoubtedly difficult financial position of many members, the Executive Committee extended from April 1 to July 1 the period within which members delinquent for last year's dues would be retained on the membership rolls, thus giving them three additional months in which to put themselves in good standing. The number of such members on June 1 delinquent for 1931 dues was 204 (compared to the corresponding figure for April a year ago of 135); and since most of this number will have to be dropped from the membership rolls on July 1, approximately 200 should be deducted from the reported membership of 4163 in making a comparison with the membership of 4327 reported June 1, 1931. In other words, there has been a drop in membership in this period of a year of approximately 365.

Realizing that many members, both individuals and companies, were resigning only with much reluctance due to extreme financial and business conditions, and desiring to aid all such members in so far as can possibly be done, the Executive Committee offered to place them on a special roll, in effect deferring action on their resignation until later in the year when it is hoped they may be in a position to continue their membership. Such members receive the BULLETIN, programs of meetings and so on, but, of course, no technical publications. Of the 309 resignations received since the first of the year, 70 accepted this offer and it is hoped that many of them will be able to retain their membership. In April, the Executive Committee, as a further aid to members, ruled that the dues might be paid in two installments, and a number of members have taken advantage of this provision. This ruling was applied likewise to new members, who have also been given the privilege of spreading the payment of the entrance fee over a period of two years.

The Society has suffered the loss by death of the following 25 members:

	DATE OF MEMBERSHIP
Ackerman, Ernest R.	1915
Bowen, H. S.	1930
Edison, Thomas A.	1916
Gilmore, Raymond B.	1927
Hilton, Alan F.	1929
Hull, Frederick A.	1916
Johnson, J. S. A.	1904
Kennedy, Jeremiah J.	1904
Klein, Henry	1928
Noyes, Stephen H.	1920
Petrenko, Serge N.	1921
Pomeroy, W. D.	1924
Read, Frank C.	1923
Riehlé, Frederick A.	1898
Skinner, Orville Campbell	1904
Slater, Willis A.	1912
Smith, Francis P.	1907
Smith, J. Hammond	1911
Spring, L. W.	1924
Swain, George F.	1896
Tiemann, Hugh P.	1910
Van Deusen, H. N.	1922
Wagner, Samuel Tobias	1899
Wardle, J. D.	1931
Wilharm, William C.	1922

In no previous year has the Society suffered through death the loss of so many active members. The above list includes several chairmen of committees and a number of others who have been most active in committee work. Appropriate notices have appeared in the Society BULLETIN.

Death twice invaded the ranks of the Executive Committee: in the loss of Vice-President Samuel Tobias Wagner on August 7, 1931, and on May 15, 1932, of H. N. Van Deusen. The Executive Committee appointed T. R. Lawson, Head, Department of Civil Engineering, Rensselaer Polytechnic Institute, to fill Mr. Wagner's unexpired term as Vice-President.

Under the inspiring leadership of Mr. Van Deusen as chairman of the General Membership Committee, the efforts begun a year ago to increase Society membership were carried on with renewed vigor and earnestness, striving to make up for losses through resignation and delinquency. Accounts of this work, which has involved the cooperation of the standing committees and many individuals of the Society, have appeared currently in the A.S.T.M. BULLETIN. The Executive Committee appreciates the great interest that many committees and members have taken in this work in the face of discouraging conditions. It will be continued along various lines during the coming year, for it is evident that despite adverse conditions there are new members to be had. The Executive Committee therefore asks the continued interest and support of the members of the Society in this work.

Much thought has been given to the importance of Student Membership. While there has been a net loss in the number of student members, this has been due partly to the introduction of the "Selected Standards for Students" into the technical schools independent of student membership. These books reach considerably over a thousand students annually and are believed, therefore, to have very distinct promotional value. Nevertheless the importance of contacts through student membership is recognized and a plan is being developed to encourage members of the Society to establish student memberships in the Society as prizes to be offered in engineering and technical schools under such terms as are mutually acceptable to the donors and the heads of the schools. Several members of the Executive Committee have taken the initiative in the establishment of such prizes, of which announcement will be made in due course in the Society BULLETIN.

Sustaining Membership.—Last year on the recommendation of the Executive Committee the Society amended the By-laws to create a class of Sustaining Membership at annual dues of $100. As the year drew to a close and the present year opened it was realized that since there was no improvement in industrial conditions it could hardly be expected that many new Sustaining Members could be acquired at this time. Nevertheless the matter was taken up informally with the representatives in the Society of some forty companies in various industries and up to the present time the following five Sustaining Memberships have been procured in the sequence indicated, by transfer from the grade of company membership: The Texas Company, Universal Atlas Cement Co., Bell Telephone Laboratories, Vacuum Oil Co. and Sun Oil Co.[1]

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[1] Since this report was written, The Western Electric Co. has become the sixth sustaining member.—ED.

The brief survey thus made of the possibilities of obtaining a substantial number of Sustaining Members has been most encouraging; approval of the general plan has been given by a number of companies who will, it is expected, increase their support of Society work in this way when business conditions improve.

A.S.T.M. Committee Activities:

It will be evident from the reports presented at this annual meeting that the committees of the Society have had an active and fruitful year. The reports of the two administrative committees, E-9 on Research and E-10 on Standards, supplemented by reviews under their sponsorship to be published in the July and October issues of the A.S.T.M. BULLETIN, will constitute a general summary of the research and standardization activities of the committees and the Society's accomplishments in these two main fields of endeavor during the past year. Therefore this report of the Executive Committee on committee activities will deal only with administrative matters.

Temporary organization of the new standing Committee C-12 on Mortars for Unit Masonry was effected during the annual meeting last year in Chicago. The committee functioned for several months under temporary officers and a temporary advisory committee, which developed plans for permanent organization that were made effective at a meeting of the committee held in Washington on February 29, 1932. R. E. Davis, Professor of Civil Engineering, University of California, was elected as chairman and F. Leo Smith, Structural Service Department, American Institute of Architects, was elected as secretary.

A new Committee D-19 on Analysis of Industrial Waters, authorization for which was announced in the Executive Committee's report a year ago, has been organized under the chairmanship of Max Hecht, Chief Chemist of the Duquesne Light Co. Due partly to industrial conditions and partly to the fact that much of the initial work of this committee dealing with development of methods of analysis of water for industrial purposes can be handled by correspondence, this committee is functioning under temporary organization. The committee will work closely with the Joint Research Committee on Boiler Feed Water Studies, on which the Society is represented.

Another new committee, E-2 on Spectrographic Analysis, was authorized by the Executive Committee after conferences with Committees E-4 on Metallography and E-1 on Methods of Testing, as well as conferences and correspondence with a number of members of the Society, had indicated a keen interest in this subject and a need for cooperative study and the development of methods. H. V. Churchill, Chief Chemist, Research Laboratories, the Aluminum Company of America, has been appointed temporary chairman and it is planned to effect organization of the committee during this annual meeting.

In view of conditions that had developed over a period of years in Committee C-4 on Clay and Concrete Pipe, the Executive Committee decided to limit the scope of Committee C-4 to Clay Pipe, reorganizing that committee with suitable personnel, and to organize a new committee to be designated Committee C-13 on Concrete Pipe, to which would be assigned jurisdiction of specifications for this product that had been developed by the original committee. The formal organization of Committee C-4 on Clay Pipe was effected at a meeting in New York on February 5, 1932; organization of Committee C-13 on Concrete Pipe will be completed at this annual meeting.

The Executive Committee is considering an important administrative question involving proper coordination of the work of Committee D-9 on Electrical Insulating Materials, dealing with a general class of materials for a specific purpose, with the work of certain other committees of the Society that deal with specific materials that are sometimes used as electrical insulators, such as Committees D-1 on Preservative Coatings for Structural Materials, D-2 on Petroleum Products and Lubricants, D-11 on Rubber Products, D-13 on Textile Materials, D-16 on Slate, and, when organized, the new Committee on Paper. Suitable means of cooperation will be established between Committee D-9 and other committees, the details to be developed in conference with the committees concerned. In the specific case of the Tentative Methods of Test for Determining the Electrical Insulating Properties of Slate (D 273 – 27 T) prepared by Committee D-16, it has been arranged that the two committees will cooperate in the further development of these methods and will hereafter be jointly responsible for them to the Society.

Committees C-9 on Concrete and Concrete Aggregates and D-4 on Road and Paving Materials, whose scopes of activity necessarily overlap in some fields, are cooperating in an endeavor to eliminate certain duplications in methods of test that have been developed by the respective committees and in other ways to bring about closer coordination of their activities.

Since the last annual meeting, the Executive Committee has approved the submission of the following specifications to the Society, which involve patents on materials or on processes or on uses, having obtained satisfactory assurance, first, that the adoption of the specifications by the Society confers a definite benefit to the consumer in defining qualities and tests to which the patented material must conform and, secondly, that the conditions under which the materials are marketed are equitable and generally satisfactory to the industries concerned:

Accepted at the 1931 Annual Meeting:

Aluminum-Base Die-Casting Alloys (B 85 - 31 T).

For Presentation at the 1932 Annual Meeting:

Specifications for Aluminum-Copper-Magnesium-Manganese Alloy Bars, Rods and Shapes,
Specifications for Magnesium-Base Alloy Sheet,
Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet),
Specifications for Ethylene Glycol Mono Butyl Ether,
Specifications for Ethylene Glycol Mono Ethyl Ether,
Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent Grade),
Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent Grade).

In accordance with the rulings of the Executive Committee, the following note will be printed with each of these specifications:

> By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

At the same time it developed that the following specifications that had been accepted by the Society for publication as tentative prior to 1931 involved patents in one way or another and the Executive Committee ruled that the above-mentioned note should be added to these specifications in the next printing:

Specifications for Magnesium-Base Alloy Castings (B 80 - 31 T),
Specifications for Soluble Nitrocellulose (D 301 - 31 T),
Specifications for Acetone (D 329 - 31 T),
Specifications for Amyl Acetate (Synthetic) (D 318 - 30 T),
Specifications for Amyl Alcohol (Synthetic) (D 319 - 30 T),
Specifications for Ethyl Acetate (85 to 88 per cent Grade) (D 302 - 30 T),
Specifications for Ethyl Lactate (Synthetic) (D 321 - 30 T),
Specifications for Normal Butyl Acetate (88 to 92 per cent Grade) (D 303 - 30 T),
Specifications for Butanol (Normal Butyl Alcohol) (D 304 - 30 T),
Specifications for Butyl Propionate (90 to 93 per cent Grade) (D 320 - 30 T).

The title of Committee E-9 on Correlation of Research has been changed to Committee E-9 on Research, conforming more nearly to the title of the companion administrative committee, E-10 on Standards.

Acting favorably upon recommendations emanating from Committee E-9 on Research and Committee E-6 on Papers and Publications, the Executive Committee has adopted the following statement of policy as a guide to the standing committees and the Committee on Papers and Publications in the development and publication of abstracts of technical literature:

1. Since special circumstances in committee work, such as need for knowledge of all available data on a rapidly developing subject, may make it desirable for a committee to prepare abstracts of the literature, it will be consistent with Society policy for such work to be undertaken by committees of the Society. Wider distribution of such abstracts other than simply among members of the committee must be determined in the light of each specific case.
2. However, in general, it is not a function of A.S.T.M. committees to engage in the work of preparing and distributing routine abstracts of the literature in their field.
3. The question whether A.S.T.M. should publish abstracts of technical literature will probably depend upon various factors differing in each particular case, and decision should be made on the merits of each case that may arise.

This statement has been transmitted to the officers of all committees of the Society.

The Executive Committee and Committee E-5 on Standing Committees have approved a modification of the standard letter ballot form appearing in the Regulations Governing Standing Committees[1] by including the following sentence in the letter ballot:

> It is requested that explanations accompany negative votes.

The purpose of this addition is obvious in that it is desirable that the standing committees themselves as well as the Society and, where it is concerned, Committee E-10 on Standards, shall be informed of the reasons why recommendations of the committees are being opposed.

Meetings and Local Activities:

The third Regional Meeting of the Society was held March 9, 1932, at Cleveland, under the auspices of the Cleveland District Committee. The technical feature was a Symposium on Rubber in two sessions, sponsored by Committee D-11 on Rubber Products and followed in the evening by an informal dinner. The symposium comprised twelve papers, all but one of which were preprinted for the meeting. The complete symposium with discussion will be published this summer. The annual spring group meetings of committees were held in Cleveland throughout the week of March 7 in conjunction with the Regional Meeting. This plan of combining these two Society activities has met with the approval of the committees and of our members in the several districts and plans are already under way for a similar Regional Meeting with the group committee meetings for 1933 in New York.

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[1] 1931 Year Book, p. 279.

In addition, since the last annual meeting a number of local meetings were held under the auspices of certain of the district committees. Three such meetings were held in New York: November 5, 1931, with the cooperation of Committee D-1 on Preservative Coatings, at which three papers were read; February 18, 1932, in cooperation with the Iron and Steel Division, Institute of Metals Division and New York Section of the American Institute of Mining and Metallurgical Engineers, on the general subject "Metals," with interesting addresses by President Clements and Past-President Moore, followed by a demonstration with explanations of various methods of testing welds; and April 28, 1932, with the cooperation of Committee D-2 on Petroleum Products and Lubricants, at which appropriate papers were presented and motion pictures shown. The New York District Committee invited to each of these meetings members of the New York sections of other societies interested in the particular subjects under discussion. The meetings proved very worth while and demonstrated that they are an effective means of bringing the work of the Society closer to its own members in the district and at the same time informing others of the nature and extent of the Society's work.

On March 28, 1932, there was held a joint meeting of the Society's members in the Detroit District with the members of the Detroit chapters of the Society of Automotive Engineers and the American Society for Steel Treating, under the general auspices of the Detroit District Committee. An excellent program of seven papers dealing with the subject "Service Testing of Automotive Products and Correlation with Laboratory Tests" was the feature of the meeting.

In Chicago on April 11, 1932, under the auspices of the Chicago District Committee, a joint meeting was held with the Western Society of Engineers, at which Past-President Moore presented an address on "Relation of Tested Material to Safe and Economic Engineering."

The Executive Committee commends these district committees for their activities during the past year and lends its encouragement to the further development of these local meetings.

1933 Annual Meeting:

As the members have already been advised through the A.S.T.M. BULLETIN, it has been decided that the annual meeting of the Society next year be held in Chicago during a suitable period, still to be determined, in the last two weeks in June. The Hotel Stevens has been selected as headquarters. Many important considerations have influenced the Executive Committee in reaching this decision; most important perhaps is the Century of Progress Fair, which will open in Chicago on June 1, 1933. The Fair features progress in the basic and applied sciences and will attract scientists and technologists the world over. Many scientific and engineering societies will meet during the period of the Fair and it is believed that by arranging our own meeting during that period we shall make it possible for our members, many of whom will attend the Fair in any event, conveniently to combine attendance at the meeting with an opportunity to visit the exposition. Plans for the meeting are now being developed in conjunction with the meeting plans of other technical societies. A feature of the meeting will be the Second Exhibit of Testing Apparatus and Machines.

Publications:

Since the last annual meeting the usual publications were issued, namely, the Proceedings, the Supplement to the 1930 Book of A.S.T.M. Standards, the Year Book and the Index to A.S.T.M. Standards and Tentative Standards, comprising the so-called "regular publications" distributed to all members. As heretofore, the Book of A.S.T.M. Tentative Standards was issued as a special publication and furnished to members on order. In addition two other special technical publications were issued and furnished to members on order: First, the complete Symposium on Welding, in cloth binding, with papers and discussions presented at the Pittsburgh Regional Meeting, March, 1931; and secondly, the Symposium on Effect of Temperature on the Properties of Metals at the 1931 Annual Meeting, sponsored and published jointly by the Society and The American Society of Mechanical Engineers. A comparative statement of the volume of these publications during the past four years follows:

	1928, PAGES	1929, PAGES	1930, PAGES	1931, PAGES
Proceedings	2088	1937	2421	2146
Book of A.S.T.M. Standards	....	....	2214	....
Supplement to Book of A.S.T.M. Standards	195	293	....	144
Year Book	309	320	332	342
Index to A.S.T.M. Standards and Tentative Standards	95	109	113	103
Book of A.S.T.M. Tentative Standards	932	901	864	1008
Regional Meeting Symposium	....	....	186	152
Joint A.S.M.E.-A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals	....	....	....	829
	3619	3560	6130	4724

A large proportion of the reports and papers making up the Proceedings had been preprinted for the annual meeting last year, the total comprising 1217 pages. In addition all the papers of the High-Temperature Symposium had been preprinted, and most of the papers for the Symposium on Welding.

Six issues of the A.S.T.M. BULLETIN were published during the year. It is very gratifying to note that despite adverse industrial conditions the income from advertising has continued to be more than sufficient to meet the cost of printing and distributing the BULLETIN, the advertising income for the calendar year 1931 being $5064, compared to a cost of printing and distributing of approximately $4640. This favorable balance is the largest yet experienced in any year since the BULLETIN was first published with advertising. On the other hand advertising in the Index to Standards and Tentative Standards for 1931 was less than for the preceding year, providing an income of $485 towards the total cost of printing and distributing 10,000 copies of the Index, which was about $1345.

In March, 1932, eleven of the twelve papers comprising the Symposium on Rubber for the Cleveland Regional Meeting were preprinted, comprising 116 pages, 1500 copies, which were distributed without charge to all members requesting copies and to members and visitors attending the symposium. The papers and discussion of the symposium will be published in a cloth-bound volume this summer and sold to members at special prices.

A number of important reprints from the 1931 Proceedings have been issued, the principal ones being: Malleable Iron Casting Symposium, 122 pp., 13,000 copies; Symposium on Abrasion Testing of Rubber, 62 pp., 500 copies; Symposium on Weathering Characteristics of Masonry Materials, 128 pp., 500 copies; Symposium on Economic Significance of Specifications for Materials, 46 pp., 4000 copies; Committee D-2 Pamphlet on Petroleum Products and Lubricants, 267 pp., 1800 copies; Committee D-9 Pamphlet on Electrical Insulating Materials, 212 pp., 750 copies; Report of Committee A-5 on Corrosion of Iron and Steel, 67 pp., 2500 copies; Edgar Marburg Lecture on "The Phenomenon of Slip in Plastic Materials," 36 pp., 1100 copies. Also a third printing, 1500 copies, of the Report of the Joint Committee on Concrete and Reinforced Concrete was made early in 1931.

The second edition of "Selected A.S.T.M. Standards for Students in Engineering" (3500 copies) was published in the fall of 1931, the two printings of the first edition having been completely sold to students in engineering in technical schools. A study of the use of this pamphlet in these schools indicated a need for a selection of standards that would be of more direct value to students in chemistry, chemical engineering, and metallurgy, and accordingly a selection of such standards was published in December, 1931, the edition being 1250 copies. While the first pamphlet seems to have become quite well established in many of the engineering schools, it is expected that some little time and effort will be required to put the second pamphlet on a comparable basis. Notwithstanding, the sales of these pamphlets during the college term just closing have been reasonably satisfactory.

The five-year Index to the Proceedings of the Society covering the years 1926 to 1930, inclusive, was published early this year and placed on sale to members at special prices.

The Executive Committee has deemed it desirable to have a study made of the possibility of publishing a journal of the Society, in view of proposals that have been advanced on various occasions that the present BULLETIN might be expanded into a technical journal. Committee E-6 on Papers and Publications has been directed to make a thorough study of the matter, giving the fullest consideration to the relationship of such a journal with the present procedure in the publication of reports and papers and in the development and publication of standards. This study is now under way.

Proposed Amendments of the By-laws:

Experience having indicated that it is desirable to make student membership in the Society available to undergraduate students in technical schools of recognized standing, other than juniors and seniors as at present required, the Executive Committee proposes that the first paragraph of Article I, Section 4 of the By-laws be amended to read as follows by striking out the words in brackets and substituting the italicized words:

> A Student Member shall be *an undergraduate* [a junior, senior] or graduate student in a technical school of recognized standing, or a student not over twenty-five years of age engaged in technical studies in an apprentice course or night school, proposed by a member of the faculty and elected by the Executive Committee.

In establishing a year ago the class of Sustaining Membership at the annual dues of $100 by appropriate amendment of Articles I and VII of the By-laws, provision for an entrance fee for Sustaining Members was inadvertently omitted. The Executive Committee believes that the entrance fee of $10 now applicable to Members should also apply to Sustaining Members and therefore recommends that the first sentence of Article VII, Section 2, of the By-laws be amended as follows by the addition of the words in italics:

> The entrance fee, payable on admission to the Society, shall be $10 for *Sustaining Members and* Members and $5 for Junior Members.

The Executive Committee asks that these two amendments of the By-laws be referred by the annual meeting to the required letter ballot vote of the membership of the Society.

Finances of the Society:

Report for Fiscal Year 1931.—The annual statement of the finances of the Society follows in the report of the auditors for the fiscal year, January 1, 1931, to December 1, 1931.

The year 1931 was a successful one financially. Although income from dues was beginning to be curtailed due to decreases in membership, this was largely offset by increases in receipts from sales of publications and from other sources, including those from the Exhibit. Since disbursements were kept well within the budget, the Society closed the year with a favorable balance, which is reflected in the increase in the surplus, from $42,532.40 on December 31, 1930, to $46,566.53 on December 31, 1931. In addition to this surplus the Society held special funds in the amount of $19,438.05 as follows: Life Membership Fund, $3005.20; A.S.T.M. Research Fund, $8387.85; Headquarters Fund, created to meet the expenses incident to possible removal of the Society's headquarters, $5030; Publications Fund, to meet cost of special or extraordinary publications, $3015. There was also set aside the sum of $5690.70 as reserve against publication of the 1933 Book of Standards. Comparison of the financial position of the Society at the close of the past five fiscal years is given at the end of the auditor's report.

The report also lists funds held for the accounts of committees and joint committees of the Society (totaling $23,491.09), and gives also a statement of the Dudley Medal and Marburg Lecture Fund, which shows a balance of $7961.57. Investments of Society and other funds are listed, being reported at book value. Although the market value of securities held by the Society has shown a depreciation in common with all securities (on December 31, 1931, this depreciation in the aggregate was approximately one-third), there has been no default in interest on any of the bonds in the Society's portfolio.

There are several features of the financial operations for the year that require special mention. The Symposium on Effect of Temperature on the Properties of Metals was published jointly by the A.S.T.M. and The American Society of Mechanical Engineers, which made it advisable to work out special plans for financing this book, comprising 829 pages, of which a final edition of 3000 cloth-bound copies was printed. In effect the societies established a "joint account," each contributing equally into this account towards the manufacturing costs, which totaled about $10,000. The societies expect that proceeds from the sales of the book, for which it is believed there will be a demand over a period of several years, will fully reimburse them for this expenditure. The symposium book was completed on February 10 and up to June 1 over half of the edition had been sold. The figure of $3673.35 that appears in the accompanying report represents the amount contributed to this joint account by the A.S.T.M. up to December 31.

The publication of the Symposium on Malleable Iron Castings held jointly with the American Foundrymen's Association was worked out on the basis of each society paying one-half of the cost of typesetting, including illustrations. The A.F.A share of this expense, $455.31, which appears as a disbursement in the accompanying report, was paid after the close of the fiscal year so that this sum will appear in the report for the current fiscal year. Each of the two societies stood the expense of printing copies of the symposium for its own use. It may be added that a similar method of financing the second of these joint symposiums, namely, that on Steel Castings, for the present annual meeting, has been adopted.

To meet anticipated needs, the sum of $1000 was taken from the Publications Fund in 1931 and placed in the budget towards the expense of publishing the papers for the Pittsburgh Regional Meeting. It was subsequently found that this expense could be met from current funds and this was done; but the amount was temporarily retained in the balance at the close of the year and not returned to the Publications Fund because of publication needs anticipated for the present year.

The first Exhibit of Testing Apparatus and Machines held with the annual meeting last year brought in total receipts of $4306.25. Expenses, including salaries and other administrative expenses properly chargeable to the exhibit, totaled approximately $3400. The favorable balance thus resulting has been applied to 1932 operations, thus spreading the proceeds over a two-year period consistent with the intention of holding such exhibits biennially.

In December, 1931, the Bulletin carried an announcement of the appointment of J. R. Dwyer as a member of the Society's staff, beginning October 1, 1931, assigned as technical assistant to Committee C-1, funds for his salary and expenses being supplied by that committee. Arrangements have been made whereby Mr. Dwyer's time is divided between the activities of Committee C-1 and those of the Cement Reference Laboratory, sponsored jointly by the Society and the U. S. Bureau of Standards; his salary is paid one-third from funds supplied by the committee and two-thirds from the funds of the Cement Reference Laboratory. All traveling expenses are paid from the first-named fund. On December 31, there was a balance in this fund of $1171.14, which appears in the statement of liabilities.

No additions from current funds were made during the year to the principal of the A.S.T.M. Research Fund, for in view of present conditions it was considered more important to conserve funds for publications than to increase the Research Fund, important though the latter undoubtedly is.

With the exception of the Society's interest in the books comprising the Symposium on Effect of Temperature on the Properties of Metals to the extent of $3673.35 as of December 31, which appears in the statement of assets, no account has been taken in the accompanying financial statement of the assets of the Society in the form of publications in stock. The inventory of technical publications on June 1, 1932, may be summarized approximately as follows:

		Number of Copies
Proceedings		6 000
Index to Proceedings	Vols. I–XII, incl	500
	Vols. XIII–XX, incl	665
	Vols. 21–25, incl	635
	Vols. 26–30, incl	610
Book of A.S.T.M. Standards	Part I, Metals	2 535
	Part II, Non-Metals	2 525
1931 Supplement to Book of A.S.T.M. Standards		4 000
Book of A.S.T.M. Tentative Standards		420
Index to Standards and Tentative Standards		1 150
Selected Standards for Students in Engineering		2 500
Selected Standards for Students in Chemistry, Chemical Engineering and Metallurgy		900
Reprints of 443 standards	(approximate)	25 000
Symposium on Effect of Temperature on the Properties of Metals		925
Special Reprints	(approximate)	12 000

REPORT OF THE AUDITORS FOR THE FISCAL YEAR, JANUARY 1, 1931, TO DECEMBER 31, 1931

PHILADELPHIA, January 7, 1932.

AMERICAN SOCIETY FOR TESTING MATERIALS,
Mr. C. L. Warwick, *Secretary-Treasurer,*
Philadelphia, Pa.

Gentlemen:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the seven months ended December 31, 1931, having previously made a similar audit and report for the preceding five months ended May 31, 1931, and at both audits found the accounts to be correct and to be in excellent condition.

We submit herewith balance sheet as of December 31, 1931, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the seven months ended December 31, 1931, as also for the five months ended May 31, 1931, as reported in ours of June 13, 1931, and found the same to be correct.

We have verified by actual inspection and count the securities as scheduled under Investments and report all interest collected to December 31, 1931, and all subsequent coupons attached. Respectfully submitted,

(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1931

ASSETS

Current Funds		$6 414.07	
Investments		49 946.21	
Accounts Receivable:			
For Publications	$3 077.81		
Advertising	1 645.00		
Members, for 1931 Dues	4 076.44		
Members, for Binding	34.00		
		8 833.25	
A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature: Special Account for Financing Book		3 673.35	
New Internat. Assn. for Testing Materials		161.46	
Furniture and Fixtures		6 571.94	
			$75 600.28

LIABILITIES

Publications paid for in advance	$1 018.32		
Advertising paid for in advance	72.00		
Members Dues paid in advance	890.96		
Members Binding paid in advance	13.00		
Entrance Fees paid in advance	145.00		
		$2 139.28	
Contributions from Committee C-1 for Technical Assistant		1 171.14	
Franklin Memorial Museum Fund		92.26	
Income, A.S.T.M. Research Fund		502.32	
Carried forward			3 905.00

Brought forward			$3 905.00	
Life Membership Fund	$3 005.20			
A.S.T.M. Research Fund	8 387.85			
Headquarters Fund	5 030.00			
Publications Fund	3 015.00			
Book of Standards Reserve	5 690.70			
		$25 128.75		
Surplus		46 566.53		
			71 695.28	
				$75 600.28

RECEIPTS AND DISBURSEMENTS
JANUARY 1, 1931, TO DECEMBER 31, 1931

Current Funds, January 1, 1931			4 567.78

RECEIPTS

Current Dues	$77 851.34		
Past Dues	644.98		
Advance Dues	865.83		
Income, Life Membership Fund	150.00		
Entrance Fees	2 890.00		
Total Dues		$82 402.15	
Separate Standards	$4 561.52		
Book of Standards	11 556.41		
Book of Standards—Members for both Parts	364.00		
Book of Tentative Standards	5 883.92		
Proceedings	3 613.58		
Collective Index to Proceedings	410.00		
Selected Standards for Students	707.75		
Miscellaneous (including special reprints)	10 456.58		
Total Sale of Publications		37 553.76	
Binding (Members)		533.00	
Advertising in Bulletin		4 954.00	
Advertising in Index to Standards and Tentative Standards		975.00	
Authors' Reprints		474.46	
Sale of Certificates of Membership		42.50	
Interest on Deposits and Investments		3 266.76	
Excess Remittances		251.85	
Prepaid Orders, A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature		391.50	
Income, A.S.T.M. Research Fund		450.00	
Registration and other fees, Annual Meeting		2 612.20	
Exhibit, Annual Meeting		4 306.25	
New Internat. Assn. for Testing Materials, Dues		381.00	
New Internat. Assn. for Testing Materials, Publications		175.80	
Franklin Memorial Museum Subscriptions		19.00	
Contributions from Committee C-1 for Technical Assistant		1 834.47	
Miscellaneous		7.50	
Total Receipts			140 631.20
Carried forward			$145 198.98

Brought forward			$145 198.98

DISBURSEMENTS

Publications:			
Year Book	$3 189.71		
Book of Standards	35.48		
Book of Standards Supplement	1 803.28		
Selected Standards for Students	732 90		
Book of Tentative Standards	3 039.65		
Proceedings	23 042.66		
Preprints	3 960.01		
Bulletin and Circulars to Members	6 682.92		
Separate Standards	1 744.89		
Authors' Reprints	581.94		
Index to Standards and Tentative Standards	1 343.95		
Regional Meeting Papers	1 028.26		
Collective Index to Proceedings	7.00		
Miscellaneous (including special reprints)	7 349.36		
		$54 542.01	
Salaries		43 813.09	
General Office Expenses		9 668.66	
Expenses, Standing Committees		2 362.31	
Expenses, Meetings		6 521.87	
Traveling Expenses—Administrative Committees		2 058.09	
Rent and Insurance, Storage Rooms		475.58	
Rent, Headquarters		3 000.00	
Headquarters Maintenance		194.50	
Furniture and Fixtures		1 100.30	
Certificates of Membership		12.50	
American Standards Association and Sectional Committees		1 900.00	
Investments		5 690.70	
A.S.T.M. Research Fund:			
Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel	$500.00		
Project Committee on Correlation of Research in Mineral Aggregates	300.00		
		$800.00	
U. S. National Committee International Electrotechnical Commission		330.00	
Central Lumber Standards Committee		25.00	
Refund of Excess Remittances		249.05	
A.S.T.M.-A.S.M.E. Symposium of Effect of Temperature		3 673.35	
Symposium on Malleable Castings (A.F.A. Share)		455.31	
New Internat. Assn. for Testing Materials, Dues		389.00	
New Internat. Assn. for Testing Materials, Publications		341.46	
Franklin Memorial Museum Subscription		200.00	
Technical Assistant, Committee C-1		663.33	
Miscellaneous		318.80	
Total Disbursements			138 784.91
Balance, Current Funds, December 31, 1931			$6 414.07

Balance accounted for as follows:		
Cash on hand	$414.07	
Baltimore & Ohio R. R. Bonds 20 year 4½'s due 1933 carried as Current Funds	15 000.00	
		$15 414.07
Less checks drawn but not paid against cost of Proceedings		9 000.00
		$6 414.07

MISCELLANEOUS FUNDS

In addition to the regular Society funds the Secretary-Treasurer has on hand the following funds, accounted for as follows:

Committee A-1 on Steel	$180.99	
Committee A-3 on Cast Iron	87.31	
Committee A-5 on Corrosion of Iron and Steel	7 502.41	
Committee A-5, Subcommittee X on Embrittlement Investigation	4 606.15	
Committee B-3 on Corrosion of Non-Ferrous Metals	4 065.01	
Committee B-6 on Die-Cast Metals and Alloys	250.45	
Committee C-1 on Cement	860.59	
Committee C-1 Cement Reference Laboratory	1 274.84	
Committee C-9 on Concrete and Concrete Aggregates	602.47	
Committee C-10 on Hollow Masonry Building Units	237.96	
Committee D-1 on Preservative Coatings	31.17	
Committee D-14 on Screen Wire Cloth	52.23	
Committee D-18 on Natural Building Stones	33.98	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	372.99	
A.S.A. Sectional Commmittee on Cast-Iron Pipe	2 014.79	
A.S.A. Sectional Committee on Classification of Coals	1 317.75	
Total Committee Funds		$23 491.09

DUDLEY MEDAL AND MARBURG LECTURE FUND

Balance, January 1, 1931:		
Investments	$6 977.50	
Cash on hand	873.08	
		7 850.58

RECEIPTS

Interest on Deposits and Investments	$404.24	
		$8 254.82

DISBURSEMENTS

Cost of 1931 Medal	$90.00	
Honorarium, 1931 Lecturer	200.00	
Engrossing 1931 Lecture Certificate	3.25	
		293.25
Balance December 31, 1931:		
Investments	$6 977.50	
Cash on hand	984.07	
		$7 961.57

INVESTMENTS, DECEMBER 31, 1931

(Reported at book value)

SOCIETY FUNDS

General:

$2 000	Michigan Central Equipment Bonds, 6's due 1932..	$2 085.96	
1 000	Baltimore & Ohio R. R. Refunding & General Mortgage Bonds, 6's due 1995.................	1 082.00	
4 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933..............................	4 606.55	
2 000	Penna. R. R. Bonds Seconds, 5's due 1964.........	2 000.00	
3 000	Am. Tel. & Tel. Co. S. F. Deb. Bonds, 5's due 1960..	3 159.75	
500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s due 1945..................................	531.00	
6 000	Southeastern Power & Light Co. 6% Gold Deb. Bonds, Series A, due 2025.....................	6 240.00	
16 000	Baltimore & Ohio R. R. Refunding & General Mortgage Bonds, 5's due 1995......................	16 200.00	
6 000	Missouri Pacific R.R. First and Refunding Mortgage 5's Gold Bonds, Series F, due 1977............	5 690.70	
$41 000			
			$41 595.96

A.S.T.M. Research Fund:

$3 000	Baltimore & Ohio R. R. Refunding & General Bonds, 6's due 1995...........................	$3 246.00	
1 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933..............................	1 511.25	
1 500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s due 1945..................................	1 593.00	
2 000	First Mortgage Real Estate 6's Bonds on 1315–17 Spruce St. due 1945..........................	2 000.00	
$8 000			8 350.25

DUDLEY MEDAL AND MARBURG LECTURE FUND

$6 500	Baltimore & Ohio R. R. Refunding and General Bonds, 6's due 1995..		6 977.50

COMMITTEE FUNDS

$7 000	U. S. Liberty Bonds, 4th 4¼'s due 1938:		
	Committee A-5..............................	$6 629.45	
	Committee C-1.............................	509.53	
			7 138.98
$62 500			$64 062.69

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1927–1931, INCLUSIVE.

Fiscal Year	Assets				Liabilities			
	Current Funds	Investments	Accounts Receivable and Miscellaneous	Furniture and Fixtures	Accounts Payable and Miscellaneous	Reserve for Book of Standards	Special Funds	Surplus
1927.......	$1 594.65	$28 403.10	$7 461.93	$5 023.49	$1 919.49	....	$5 051.20	$35 512.48
1928.......	978.56	44 752.09	6 831.10	5 327.09	972.04	$6 057.80	10 354.30	40 504.70
1929.......	3 683.76	54 707.09	6 226.93	5 896.31	1 913.27	12 012.80	19 438.05	37 149.97
1930.......	4 567.78	44 255.51	10 873.38	6 209.36	2 935.58	....	20 438.05	42 532.40
1931.......	6 414.07	49 946.21	12 668.06	6 571.94	3 905.00	5 690.70	19 438.05	46 566.53

1932 Finances.—The Society's activities for the current fiscal year have been based on a budget that anticipates income materially lessened by the effect of present industrial conditions upon receipts from membership dues and to a somewhat uncertain extent upon sales of publications. Receipts have been estimated at approximately $125,000; in addition, the Executive Committee has set aside from the 1931 balance the sum of approximately $5000 as a contingency fund to be applied to 1932 operations if expected income is not fully realized.

In view of the uncertainties of the estimated receipts, the budget of disbursements drawn up at the beginning of the present fiscal year was on a more or less tentative basis, subject to review and modification at the annual meeting, by which time it should be possible to predict total income with reasonable certainty and to balance the budget for the year. Disbursements totaling $125,000 (equivalent to the estimated receipts above mentioned) were tentatively budgeted, providing for substantially all Society activities without serious curtailment of any essential service to the membership. It has been necessary to accept a somewhat smaller number of technical papers for the annual meeting than during the past several years and to ask the standing committees to present their reports as concisely as possible to conserve space. In this direction the committees have cooperated splendidly; and while appendices in a few committee reports have not been preprinted, it is hoped that all committee reports can finally be published in full. There has been no curtailment of publication of the Society's standardization work, all proposed new standards and revisions having been published; but committees have been requested for reasons of economy to defer until next year, where possible without inconvenience to the committee or to the industries concerned, the advancement to standard of revisions in standards and of existing tentative standards. A modification of the plan of distributing preprints at the annual meeting, together with economies being effected in various publications—supplemented, fortunately, by general reductions in printing costs—are resulting in substantial savings. Also the expenses of the annual meeting are being kept to a minimum.

Publicity and Promotional Activities:

In its report a year ago the Executive Committee outlined those publicity and promotional activities that it felt should be developed as effectively as possible within the means available. These involve fundamentally the extension of the gathering and disseminating through appropriate channels of information about work that is being done throughout the Society, particularly in the standing and research committees; expansion of the Society BULLETIN; dignified publicity of annual, regional and local meetings and meetings of committees; periodic news releases to the technical and trade press; wider dissemination of the standards of the Society; and such miscellaneous things as preparation of special articles, development of contacts with industry and industrial groups, and so on. Rather gratifying progress has been made in this work during the past year.

To stimulate the sales of reprints of standards and as an aid to their wider dissemination above referred to, the Executive Committee has substantially reduced the sales price of separate copies of the standards and tentative standards, particularly for copies ordered in quantity. The new scale, which was first announced in the April, 1932, BULLETIN, is as follows:

Single copies and up to 24	25 cents per copy
25 to 99 copies	20 cents per copy
100 to 249 copies	15 cents per copy
250 and above	special quotations

It is intended to encourage use of the separate reprints in quantity, particularly by companies who are producing or purchasing materials in conformity with the specifications and tests of the Society.

Experience has shown that the technical and trade press welcomes news about activities within the Society. The reviews of committee activities that appear from time to time in the BULLETIN are being helpfully supplemented by special articles describing particular research and standardization projects going on in the Society, which for the most part are being prepared by the committees themselves. The Executive Committee would point out that this type of publicity has a far-reaching influence in acquainting people and industries with the Society and its work and will pay for itself many times over in the increased use that is made of the standards and publications of the Society and in building up membership.

Exhibit of Testing Apparatus and Machines:

Inasmuch as a complete account of the first Exhibit of Testing Apparatus and Machines held in conjunction with the annual meeting last year appeared in the July, 1931, issue of the A.S.T.M. BULLETIN, the Executive Committee desires here simply to record the fact that in every way this exhibit exceeded our best expectations. Members and exhibitors expressed most favorable opinions, commending the scientific and educational atmosphere that was evident throughout the exhibit. Many new and unusual testing machines and devices were shown, and both industrial exhibitors and research laboratories cooperated with the Society most effectively to make the exhibit of interest and value.

After obtaining the views of many members and of the exhibitors themselves, the Executive Committee concluded that an exhibit of this kind should preferably be held not annually but every other year. Accordingly no exhibit will be held with the annual meeting this year, but as previously mentioned it is planned to hold the second exhibit in conjunction with the annual meeting in 1933.

Edgar Marburg Lecture for 1932:

Upon recommendation of the Edgar Marburg Lecture Committee consisting of K. G. Mackenzie, chairman, Arthur W. Carpenter and H. F. Moore, the Executive Committee has invited Hugh Stott Taylor, Professor of Chemistry at Princeton University, to deliver the seventh Edgar Marburg Lecture at this annual meeting. Professor Taylor will speak on "Fundamentals in the Problem of Resistance to Deterioration."

Charles B. Dudley Medal:

The Committee on Medal Award consisting of E. L. Lasier, chairman, J. B. Johnson and J. C. Pearson, made a unanimous recommendation to the Executive Committee for the award of the Charles B. Dudley Medal for this year. The award was made to C. A. Menzel, Associate Engineer, Portland Cement Association, for his paper on "Tests of the Fire Resistance and Stability of Walls of Concrete Masonry Units," presented at the annual meeting of the Society a year ago.

American Standards Association:

Inasmuch as Committee E-10 on Standards is in immediate charge of the administrative details of the Society's relationships with the American Standards Association and the current report of that committee covers these details, this portion of the report of the Executive Committee is confined to certain general administrative matters.

The amendments of the Constitution of the American Standards Association, which were outlined briefly in the last annual report, were formally approved for the Society by the Executive Committee at its meeting last June. This revised Constitution was formally ratified by the member bodies and has been in effect since July, 1931.

The Executive Committee also approved the Constitution of the Electrical Standards Committee, which was organized last October under the Constitution and Procedure of the A.S.A. for the purpose of providing a single central standardizing committee within the field of the electrical industry. This committee will serve as an advisory committee to the A.S.A. for the correlation of electrical standardization matters under any of the recognized procedures. The coordination of American participation in international projects in the electrical field is a very important function of the committee, to which end it has, with certain additions, been also organized as the U. S. National Committee of the International Electrotechnical Commission. The Society's representative on the Electrical Standards Committee as well as on the reorganized U. S. National Committee of the I.E.C. is Past-President F. M. Farmer, Chief Engineer, Electrical Testing Laboratories; the Secretary-Treasurer serves as alternate.

The Executive Committee acting for the Society agreed to join with the other sponsors of the Sectional Committee on Wire and Cables in withdrawing from sponsorship and approving the designation of the Electrical Standards Committee as sole sponsor.

Negotiations are in progress with the Electrical Standards Committee and the American Standards Association looking to the development on a broad scale of a project dealing with the formulation of American standard methods of test for electrical insulating materials, which involves the organization of Committee D-9 on Electrical Insulating Materials as a sectional committee under A.S.A. procedure and A.S.T.M. sponsorship.

A Sectional Committee on Sieves for Testing Purposes was organized on December 15, 1931, under the joint sponsorship of the U. S. Bureau of Standards and the A.S.T.M.

Past-President A. A. Stevenson has been re-appointed as one of the Society's representatives on the Standards Council for a term of three years.

International Standards Association:

As reported last year, the American Standards Association has assumed the secretariat under I.S.A. procedure for the project dealing with international consideration of Methods of Test and Nomenclature of Petroleum Products. Inasmuch as the A.S.T.M. is sponsor for American standardization in this field under A.S.A. procedure the secretariat has been organized with the cooperation of A.S.T.M. through the appointment of R. P. Anderson, Secretary, Division of Refining, American Petroleum Institute, and secretary of Committee D-2 on Petroleum Products and Lubricants, as American member of the I.S.A. committee on this subject.

There appears to be some danger of duplication of effort and resulting confusion due to the fact that several other international bodies have announced the organization of groups or commissions to do certain international work in this field. It has seemed to the Executive Committee that the International Standards Association, because of the direct representation therein of the national standardizing bodies of many countries, is in a better position than other less formally constituted international bodies to bring about unification of methods of test and nomenclature in this field. A statement of these views has been transmitted to the American Standards Association.

New International Association for Testing Materials:

The Congress of the International Association for Testing Materials was held September, 1931, in Zurich. Mr. W. H. Fulweiler, American Member of the Permanent Committee, having been unable to attend the Congress, was represented at the Congress and in the Permanent Committee of the N.I.A.T.M. by Past-President H. F. Moore. Announcements respecting the Congress and the publications of the Congress Proceedings, for which orders from the members have been solicited, have been made from time to time directly to the American members of the N.I.A.T.M. and in the A.S.T.M. BULLETIN.

At the Zurich Congress, Dr. G. K. Burgess, Director of the U. S. Bureau of Standards and a Past-President of the Society, was elected as chairman of Section D, of the N.I.A.T.M., on Matters of General Interest. He was subsequently appointed by the Executive Committee of the Society to be the American member of the Permanent Committee. Due to illness, Doctor Burgess was unable to take up at once the duties of his position and Mr. Fulweiler consented to continue temporarily as the American member.

As mentioned in the report a year ago, the cost of the four volumes of "First Communications" comprising preliminary reports on a variety of subjects, issued in advance of the Zurich Congress, considerably exceeded the financial resources of the N.I.A.T.M. Since the Executive Committee felt that it would not be proper to assume any of this deficit from the general funds of the Society, inasmuch as only a relatively small proportion of the members of the Society are members of the International Association, it was decided to request the American members of the International Association to make such voluntary contributions as they wished to help meet this deficit. Such contributions were requested but fell far short of the "quota" of the deficit apportioned to this country. These efforts will be supplemented by direct appeals from the Association. The Executive Committee has stated to the Permanent Committee its view that these preliminary publications do not serve a sufficiently worth-while purpose to warrant the expense of publication and has recommended that they be discontinued.

At the Zurich Congress it was decided that the dues of individual members of the International Association would be increased from $1 to $2 per year and those of company members from $2 to $4 per year. This action seems to the Executive Committee to be fully justified since it has become evident that the original dues were inadequate for financing the expenses of the Association.

The Executive Committee understands that certain "commissions" are being formed in the various sections of the International Association dealing with subjects that may be of quite direct interest to committees of the Society. Further information is being sought respecting the nature, scope and functions of these commissions.

It is planned to hold the next Congress of the International Association in London, probably in 1935.

Miscellaneous Cooperative Work:

Much cooperative work with other organizations in addition to that previously recounted in this report is carried on each year on an established and practically routine basis through joint committees, representation of other societies on A.S.T.M. committees and Society representation upon committees of other organizations.

The Society has become a member of the Inter-Society Color Council, which has developed from the conferences held under the auspices of the Optical Society of America, as reported a year ago.

The Society for some little time has been cooperating with the Society of Automotive Engineers in several fields of mutual interest, notably that of petroleum products and lubricants. There is now being discussed with the executives of the S.A.E. a plan for closer cooperation between the two societies and proper coordination of their activities in the development of standards for non-ferrous metals and alloys for use in the automotive field.

The Society has continued to maintain contact with the Scientific Apparatus Makers of America to procure their criticisms and comments on those portions of committee reports dealing with testing apparatus.

The Executive Committee has appointed Past-President K. G. Mackenzie and President F. O. Clements to serve as our representatives on the Division of Engineering and Industrial Research, National Research Council.

Some changes in the representation of the Society on the Joint Committee on Concrete and Reinforced Concrete were necessitated by the resignation therefrom of Cloyd M. Chapman. The Executive Committee appointed Stanton Walker, Director of Engineering and Research, National Sand and Gravel Association, to succeed Mr. Chapman as a member of the committee, and at the same time appointed P. H. Bates to succeed Mr. Chapman as chairman of the A.S.T.M. representatives on the committee, now comprising the following: P. H. Bates, A. T. Goldbeck, E. E. Hughes, L. S. Moisseiff and Stanton Walker.

With the approval of the Executive Committee, the Chicago District Committee has affiliated with the recently organized Chicago Engineering Council, whose purposes are, briefly, to supply a medium for the meeting and exchange of ideas and information between members of the various engineering and allied technical professions in Chicago. It is felt that such affiliation will be of direct value to the District Committee in furthering the purposes for which it is organized.

The Executive Committee has appointed P. J. Freeman as the Society's representative on the Joint Committee on Research in Mineral Aggregates; and has approved the appointment of R. A. Bull, P. E. McKinney and C. L. Kinney as members of the Joint Research Committee on Effect of Temperature on the Properties of Metals.

Other appointments made to committees of the Society, to A.S.A. sectional committees and others have been announced currently in the A.S.T.M. BULLETIN.

Respectfully submitted on behalf of the Executive Committee,

F. O. CLEMENTS,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL

During the past year the committee has held two meetings, on January 15, and on March 11, 1932. A third meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters considered.

The Advisory Committee has held three meetings at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 188, of which 86 are classified as producers, 77 as consumers and 25 as general interests.

At a meeting of the committee held during the annual meeting of the Society at Chicago, Ill., in June, 1931, Subcommittee IX on Steel Tubing and Pipe presented proposed Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 - 31 T), Electric-Resistance-Welded Steel Pipe (A 135 - 31 T), Forge-Welded Steel Pipe (A 136 - 31 T), Lock-Bar Steel Pipe (A 137 - 31 T), and Riveted Steel and Wrought-Iron Pipe (A 138 - 31 T), which had been prepared by the subcommittee too late for inclusion in the 1931 report. These proposed tentative specifications were subsequently presented to the Society through Committee E-10 on Standards and were accepted for publication as tentative on August 6, 1931.[1] The new tentative standards were published in the 1931 *Proceedings*.[2]

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to in greater detail under activities of subcommittees, being grouped for convenience in the order of the respective subcommittee directly responsible for them.

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[1] In submitting the specifications to Committee E-10 the committee reported the following results of the letter ballot vote from a total of 124 ballots returned: Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 - 31 T), 88 affirmative, none negative with 36 members not voting; Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 - 31 T), 86 affirmative, none negative with 38 members not voting; Tentative Specifications for Forge-Welded Steel Pipe (A 136 - 31 T), 86 affirmative, none negative with 38 members not voting; Tentative Specification; for Lock-Bar Steel Pipe (A 137 - 31 T), 82 affirmative, none negative with 42 members not votings Tentative Specifications for Riveted-Steel and Wrought-Iron Pipe (A 138 - 31 T), 86 affirmative, none negative with 38 members not voting.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 673 to 693, inclusive (1931).

Proposed New Tentative Standards.—The committee recommends that the following proposed tentative specifications be accepted for publication as tentative as appended hereto:[1]

Proposed Tentative Specifications for Structural Medium Steel, as prepared by Subcommittee II;

Proposed Tentative Specifications for Structural Rivet Steel, as prepared by Subcommittee II;

Proposed Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.), as prepared by Subcommittee IX.

Proposed Tentative Revisions of Standards.— The committee recommends revisions in existing standards, which are given in full in the Appendix to this report, for publication as tentative. These revisions are divided into two groups, one group of specifications in which a common change in respect to the process clause is being recommended, and a second group in which miscellaneous revisions are recommended.

Proposed Revision in Process Clause.—The subject of revising the process clauses of the steel specifications by the addition of "acid" in referring to the bessemer process, to meet the objection that had been raised against the continuance in some specifications of permission to use bessemer steel, was discussed by Committee A-1 on Steel and by the Advisory Committee in January, 1931. This subject was subsequently referred to the various subcommittees having jurisdiction over the specifications involved. These subcommittees were the following:

Subcommittee I on Steel Rails and Accessories
Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock
Subcommittee V on Steel Reinforcement Bars
Subcommittee IX on Steel Tubing and Pipe
Subcommittee XV on Commercial Bar Steels

After consideration, a number of subcommittees reported to the committee their approval of revising the process clauses by addition of "acid" in referring to the bessemer process. These proposed revisions were included in the preprint of the 1931 annual report of Committee A-1 but before the report was presented to the Society at the annual meeting attention was called to the fact that the report did not include, in explanation, reasons for proposing this amendment in the standards, as required by the regulations. To obviate any criticism on this score, and as two subcommittees had not reported in time to have their action included in the report of A-1, although it was known their action was favorable, it was decided to withdraw the subject in order to permit further consideration and re-submit it to the Society in 1932.

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[1] See pp. 534, 540 and 564, respectively.—ED.

The committee is now recommending, as mentioned in detail in the Appendix, revisions in the process clauses of the following standard and tentative standard specifications:

Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24)
Standard Specifications for Structural Steel for Buildings (A 9 – 29)
Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30)
Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 30)
Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 24)
Standard Specifications for Quenched Alloy-Steel Track Bolts (A 51 – 21)
Standard Specifications for Steel Tie Plates (A 67 – 30)
Tentative Specifications for Soft Steel Track Spikes (A 65 – 26 T)
Standard Specifications for Steel Screw Spikes (A 66 – 21)
Standard Specifications for Low-Carbon-Steel Track Bolts (A 76 – 27)
Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27)
Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T)
Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30)
Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30)
Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T)

In substantiation of the changes proposed in the process clauses of the above specifications, the following is presented:

1. Very little basic bessemer steel was ever manufactured in the United States and none prior to the time the various A.S.T.M. specifications were adopted. The raw materials in the United States are not suitable for its manufacture.

2. Phosphorus limits specified in the various A.S.T.M. specifications indicate the limit necessary for acid-bessemer steel. If there

had been any question of including basic bessemer, a separate limit no doubt would have been established as is the case in certain standard specifications which differentiate between acid and basic open-hearth steels.

3. The producing interests on the A.S.T.M. committees should not draft specifications for material with the manufacture of which they have had no practical experience.

4. During the past two years a number of corrections in steel specifications have been made by Committee A-1 to clear up requirements that had stood for long periods of time because questions were raised about points that the subcommittees supposed were common knowledge when the specifications were written.

5. The Society should not regard this as a revision but as a technical correction and it should not involve the introduction of a controversy as to the relative merits or demerits of basic bessemer steel. Neither should the Society concern itself with the economic question advanced. A.S.T.M. specifications are American standards based on American practice. Purchasers frequently modify them to suit their particular needs and under the proposed change it would only be necessary for the purchaser in the use of any of the specifications involved to specify that basic bessemer will be acceptable.

Revisions in the following standards which are given in full in the Appendix are recommended for publication as tentative revisions:

Standard Specifications for Structural Steel for Buildings (A 9 - 29);
Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 - 30);
Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 - 14);
Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 30);
Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 - 30).

Proposed Revisions of Tentative Standards.—The committee recommends that the following tentative specifications be revised as given in detail in the Appendix, and the specifications as revised continued as tentative:

Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 31 T);
Tentative Specifications for Soft Steel Track Spikes (A 65 - 26 T);
Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 - 28 T);

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 – 31 T);
Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 31 T);
Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 31 T);
Tentative Specifications for Lock-Bar Steel Pipe (A 137 – 31 T);
Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T).

Withdrawal of Standard.—The committee recommends the withdrawal of the Standard Specifications for Extra-High-Carbon-Steel Splice Bars (A 6 – 14).[1]

The above recommendations have been referred to letter ballot of the committee, which consists of 188 members; 105 ballots have been cast, 83 members having failed to return their ballots. The analysis of the vote of the committee is given in Table I.

Table I.—Analysis of Letter Ballot Vote.

Items	Affirmative	Negative	Not Voting
I. Proposed New Tentative Standards			
Specifications for Structural Medium Steel	70	0	35
Specifications for Structural Rivet Steel	64	0	41
Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.)	60	1	44
II. Proposed Tentative Revisions of Standards			
Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24)	53	2	50
Specifications for Quenched Carbon-Steel Track Bolts (A 50 – 24)	54	1	50
Specifications for Quenched Alloy-Steel Track Bolts (A 51 – 21)	53	1	51
Specifications for Steel Screw Spikes (A 66 – 21)	49	1	55
Specifications for Steel Tie Plates (A 67 – 30)	54	1	50
Specifications for Low-Carbon-Steel Track Bolts (A 76 – 27)	53	1	51
Specifications for Structural Steel for Buildings (A 9 – 29)	64	2	39
Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30)	59	2	44
Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14)	52	2	51
Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27)	50	1	54
Specifications for Welded and Seamless Steel Pipe (A 53 – 30)	65	2	38
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 30)	55	1	49
Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30)	70	2	33
Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30)	65	2	38
Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30)	69	1	35
III. Proposed Revisions in Tentative Standards			
Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 31 T)	68	1	36
Specifications for Soft Steel Track Spikes (A 65 – 26 T)	54	2	49
Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T)	56	2	47
Specifications for Electric-Fusion-Welded Steel Pipe (A 134 – 31 T)	55	1	49
Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 31 T)	55	0	50
Specifications for Forge-Welded Steel Pipe (A 136 – 31 T)	54	1	50
Specifications for Lock-Bar Steel Pipe (A 137 – 31 T)	49	0	56
Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T)	52	0	53
IV. Withdrawal of Standard			
Specifications for Extra-High-Carbon-Steel Splice Bars (A 6 – 14)	52	1	52

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 40.

SUBCOMMITTEE ACTIVITIES

In the following, the committee presents the foregoing recommendations in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective subcommittee dealing with the subject.

Subcommittee I on Steel Rails and Accessories (E. F. Kenney, chairman).—In order to provide for spikes made by manufacturers who do not make their own steel, a revision of the Tentative Specifications for Soft Steel Track Spikes (A 65 – 26 T), shown in the Appendix, is recommended. A further revision providing for the substitution, at the option of the manufacturer, of tensile strength requirements in place of chemical analysis will be presented to Committee A-1 at the June meeting.[1]

The Standard Specifications for Extra-High-Carbon-Steel Splice Bars (A 6 – 14) were found to be in disuse, and the subcommittee accordingly recommends they be discontinued.

Tentative revisions in the process clauses of the Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24), Steel Track Spikes (A 65 – 24), Steel Screw Spikes (A 66 – 21), Low-Carbon-Steel Track Bolts (A 76 – 27), Quenched Carbon-Steel Track Bolts (A 50 – 24), Quenched Alloy-Steel Track Bolts (A 51 – 21) and Steel Tie Plates (A 67–30), as explained in detail in the Appendix, are being recommended.

Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman).—Subcommittee II has prepared new proposed Tentative Specifications for Structural Medium Steel, appended hereto.[2] These specifications, the chief feature of which is a tensile strength of 60,000 to 72,000 lb. per sq. in., are the result of a considerable demand for this type of steel for heavy construction. The subject has been before the committee for the past six years; canvasses have been made to determine the demand existing for such a specification, and in the opinion of the subcommittee its promulgation is now desirable.

New proposed Tentative Specifications for Structural Rivet Steel, appended hereto,[3] have been prepared with the cooperation of the manufacturers. The purpose in drafting these specifications is to have a distinct specification for this product instead of a few clauses pertaining to rivet steel in otherwise unrelated specifications. It is the intention of the committee, upon the subsequent adoption of the specifications as standard, to recommend the withdrawal of those sections pertaining to rivets in the structural steel specifications.

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[1] See Editorial Note, p. 78.—ED.

[2] See p. 534.—ED.

[3] See p. 540.—ED.

The committee also recommends, as given in the Appendix, a tentative revision in the Standard Specifications for Structural Steel for Buildings (A 9 – 29), limiting the thickness of punched plates and angles on which bessemer steel shall be used to conform with a limit now established by the manufacturers. A revision in the process clause of these specifications, referred to in detail earlier in the report is also recommended.

A sub-subcommittee is investigating the demand for a higher strength rivet steel for use with structural silicon steel.

Subcommittee III on Structural Steel for Ships (R. C. Davis, chairman).—The activities of Subcommittee III for the past year have been confined to an exhaustive review of its recently accepted Tentative Specifications for Structural Steel for Ships (A 131 – 31 T) all points of which have been reconsidered, reviewed with other interested bodies, and reaffirmed. The subcommittee is reviewing the possibilities of a higher strength steel for special types of construction.

Subcommittee IV on Spring Steel and Steel Springs (H. W. Faus, chairman).—The Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 31 T) are being continued as tentative inasmuch as these specifications have been submitted to the Committee on Specifications of the American Railway Association which committee may propose further changes. A revision of these specifications presented last year may also be subject to revision.

Subcommittee V on Steel Reinforcement Bars (H. H. Morgan, chairman).—Proposed tentative revisions in method of bend testing, elimination of the machining clause, and changes defining "lot" and "theoretical weight" are recommended by Subcommittee V in the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) and Rail-Steel Concrete Reinforcement Bars (A 16 – 14) as shown in full in the Appendix. A revision in the process clause of the Standard Specifications A 15 is also recommended.

Subcommittee VI on Steel Forgings and Billets (R. W. Steigerwalt, chairman).—The subcommittee has suffered the loss of its chairman, Mr. H. P. Tiemann, by death during the past year. The deep regret of the members of the subcommittee and of Committee A-1 is expressed by formal resolutions drawn up and adopted by Committee A-1 as follows:

> The A.S.T.M. Committee on Steel, Committee A-1, at its meeting in Philadelphia, January 15, 1932, by resolution voiced the desire felt by the individual members that there be placed in the records an expression of appreciation of

the work of the late Hugh P. Tiemann; also that word of this action be messaged to his family and business associates.

In addition to his membership on Committee A-1, as a representative of Carnegie Steel Co., Mr. Tiemann through a long term of years was chairman of Subcommittee VI on Steel Forgings and Billets. Throughout that period the work of the subcommittee was marked by sustained activity in the framing and reframing of the several A.S.T.M. standard specifications under the charge of the subcommittee, which specifications have taken their place not only as American standards but are recognized internationally.

Throughout his chairmanship, Mr. Tiemann showed himself to be true to the ideals of the Society, fair to an opponent in an argument and a good loser when overruled by the prevailing thought.

In these minutes we desire to express for Committee A-1 and its subcommittees some measure of their appreciation of his service for and lasting influence upon the phases of engineering to which Mr. Tiemann's business life was devoted.

We also desire to express not only for ourselves as friends and associates, but for the individual members of these committees, so far as we can, our deep sense of personal loss in his passing. During the years of association we have acquired a high estimate of Mr. Tiemann in the personal sense, which estimate will, we believe, lose nothing with the perspective time.

Subcommittee VIII on Steel Castings (W. C. Hamilton, chairman).—Subcommittee VIII is cooperating in arranging for a Symposium on Steel Castings sponsored jointly by the American Foundrymen's Association and the American Society for Testing Materials at the June, 1932 meeting of the Society.[1]

Sub-subcommittees are at work on alloy-steel castings and on standardization of specifications.

The subcommittee recommends the addition of "carbon" to the title of the Standard Specifications A 27 – 24,[2] thus changing it to read "Standard Specifications for Carbon-Steel Castings," which will definitely describe the material. A revision of the scope clause, for the same purpose, is also recommended, changing the first sentence to read "These specifications cover carbon-steel castings for general service and for ships;" also a change in the phraseology in Section 3 (*c*) and (*d*) inserting "full" before "annealing" to conform to the accepted nomenclature. As these revisions are matters of form only they are being made as editorial changes.

Subcommittee IX on Steel Tubing and Pipe (H. H. Morgan, chairman).—Subgroups of this subcommittee handling the Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 – 31 T), Electric-Resistance-Welded Steel Pipe (A 135 – 31 T), Forge-Welded Steel Pipe (A 136 – 31 T), Lock-Bar Steel Pipe (A 137 – 31 T) and Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T) have received and considered all criticisms to these tentative specifications and are recommending various changes as shown in the Appendix, and where the changes are general the complete specifications have been appended in their revised form.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, pp. 43–292 (1932).

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 227.

As the result of a request from the Boiler Code Committee of the American Society of Mechanical Engineers, the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 30) have been revised to provide for higher tensile strength boiler tubes. The revised specifications are being issued in the form of separate tentative specifications, appended hereto,[2] to supersede when adopted as standard, the present specifications.

The subject of specifications for electric-fusion-welded steel pipe will now be covered by two specifications, one for pipe under 30 in. in diameter which is fabricated at the point of steel manufacture, used for purposes similar to the Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 30); and the other for pipe 30 in. and over in diameter used for projects where riveted steel pipe is used. The present Specifications A 134 - 31 T, mentioned above, are being revised by the deletion of portions applying to pipe under 30 in. in diameter, these specifications thus covering pipe 30 in. and over in diameter. New proposed Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.), as appended hereto,[3] have been prepared to cover the other class.

Revisions in the process clauses of the Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 30) and Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 - 28 T) are also being recommended as given in Appendix I.

Subcommittee XI on Boiler Steel (E. J. Edwards, chairman).—A sub-subcommittee of Subcommittee XI is actively engaged in investigating the demand existing for and the material and properties necessary for a higher tensile strength steel for boiler and firebox requirements. A further investigation along the same lines is being made on rivet bars.

Subcommittee XV on Commercial Bar Steels (J. J. Shuman, chairman).—Subcommittee XV is recommending a revision in the process clauses of the Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 - 30) and Standard Specifications for

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[1] See pp. 560 to 588.—ED.

[2] See p. 549.—ED.

[3] See p. 564.—ED.

Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30) as detailed in the Appendix.

Subcommittee XVI on Cast Steel Chain (F. M. Waring, chairman).—At the request of the subcommittee, who felt their work completed, this subcommittee was discontinued.

Subcommittee XXI on Steel for Welding (F. N. Speller, chairman).—Subcommittee XXI has recommended revisions of the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30) and Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T) pertaining to this material when used for fusion welding. These changes are shown in the Appendix.

Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service (A. E. White, acting chairman).—A subsubcommittee is reviewing the Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29) with a view towards further restrictions. Another subgroup has agreed to undertake the preparation of specifications for castings, bolting, flanges and pipe for temperatures above 750 and up to 850° F.

The members of Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service of A.S.T.M. Committee A-1 on Steel sustained a very serious loss in the death on March 23, 1932, of LaVerne W. Spring, chairman of the subcommittee. Our deceased chairman, during the entire period of the subcommittee's existence, made contributions in technical data, in conclusions from experience, and in efforts to harmonize differences of opinion, which combined to make Mr. Spring an outstanding member of this subcommittee and of the Society. It has been a source of gratification to all of us to see the honors conferred on our friend by the American Society for Testing Materials, the American Foundrymen's Association and other technical organizations with which our former chairman was connected. Therefore,

BE IT RESOLVED, by the members of Subcommittee XXII of Committee A-1 of the American Society for Testing Materials that this, our written tribute to the great value of Mr. Spring's services, be spread upon the minutes of this subcommittee; and be reported formally to Committee A-1, as action commemorative of our deceased chairman, for whom we felt an affection growing out of his high personal qualities, which supplemented his technical qualifications.

BE IT FURTHER RESOLVED, that a copy of these resolutions, as an indication of the respect and personal regard of the members of Subcommittee XXII for their deceased chairman, be transmitted to Mrs. LaVerne W. Spring. In sympathizing deeply with her children, and particularly with Mrs. Spring, we hope that our appreciation of her husband's character and services will help to temper the sorrow caused by the untimely death of a man who provided an enduring inspiration to those who would be honest, tolerant, industrious and intelligent, and

BE IT FURTHER RESOLVED, that a copy of these resolutions be transmitted to the Crane Company, helpful member of this Society for 24 years, now deprived of the services of Mr. Spring as Chief Chemist and Metallurgist; therefore, also deserving of the sympathy we extend.

Subcommittee XXIII on Die Steel For Die Casting Dies (R. G. Roshong, chairman).—This new subcommittee was formed to take up special features of the work of Subcommittee XIV on Tool Steel now discontinued. The subcommittee has inaugurated a vigorous program of fact finding and testing in connection with this new subject.

This report has been submitted to letter ballot of the committee, which consists of 188 members; 105 members returned their ballots, of whom 98 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. B. YOUNG,
Chairman.

V. H. LAWRENCE,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Structural Rivet Steel and for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) were accepted for publication as tentative and appear on pages 540 and 564, respectively. The proposed Tentative Specifications for Structural Medium Steel were accepted with a change in the scope clause proposed on the floor of the annual meeting, see Summary of Proceedings, page 17, for publication as tentative and appear in their revised form on page 534.

The proposed revisions of the Standard Specifications for Low-Carbon-Steel Splice Bars, for Quenched Carbon-Steel Track Bolts, for Quenched Alloy-Steel Track Bolts, for Steel Screw Spikes, for Steel Tie Plates, for Low-Carbon-Steel Track Bolts, for Structural Steel for Buildings, for Billet-Steel Concrete Reinforcement Bars, for Rail-Steel Concrete Reinforcement Bars, for Cold-Drawn Steel Wire for Concrete Reinforcement, for Welded and Seamless Steel Pipe, for Commercial Quality Hot-Rolled Bar Steels, for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting and for Steel Plates of Structural Quality for Forge Welding were accepted for publication as tentative and appear on pages 973 to 980.

The proposed revision of the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, in the form of new tentative specifications, was accepted for publication as tentative. Additional revisions of these tentative specifications were subsequently accepted on August 11, 1932, by Committee E-10 on Standards. The tentative specifications in the form as amended appear on page 549.

The proposed revisions of the Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding, for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses, for Electric-Fusion-Welded Steel Pipe, for Electric-Resistance-Welded Steel Pipe, for Forge-Welded Steel Pipe, for Lock-Bar Steel Pipe and for Riveted Steel and Wrought-Iron Pipe were accepted. The specifications in their revised form appear on pages 543 to 588.

The proposed revision of the Tentative Specifications for Soft Steel Track Spikes with additional changes proposed on the floor of the annual meeting, see Summary of Proceedings, page 18, was accepted. The specifications in their revised form appear on page 531.

The withdrawal of the Standard Specifications for Extra-High-Carbon Steel Splice Bars was approved.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this appendix are given proposed revisions in certain standard and tentative specifications covering steel and steel products. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

Proposed Tentative Revisions of Standards

Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 - 24),[1] *and for Steel Screw Spikes (A 66 - 21):*[2]

Section 1.—Change to read as follows by the addition of the italicized word:

1. The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 - 24)[3] *and for Quenched Alloy-Steel Track Bolts (A 51 - 21):*[4]

Section 1 (b).—Change to read as follows by the addition of the italicized words:

(*b*) The steel for the nuts shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

Standard Specifications for Steel Tie Plates (A 67 - 30):[5]

Section 2.—Change to read as follows by the addition of the italicized words:

2. The steel shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

Standard Specifications for Low-Carbon-Steel Track Bolts (A 76 - 27):[6]

Section 1 (a).—Change to read as follows by the addition of the italicized word:

1. (*a*) The steel shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 30.

[2] *Ibid.*, p. 61.

[3] *Ibid.*, p. 51.

[4] *Ibid.*, p. 55.

[5] *Ibid.*, p. 63.

[6] *Ibid.*, p. 47.

Standard Specifications for Structural Steel for Buildings (A 9 – 29):[1]

Section 1.—Change to read as follows by the addition of the italicized word and figure and the omission of the figure in brackets:

1. (*a*) Structural steel, except as noted in Paragraph (b), shall be made by either or both the following processes: *acid*-bessemer or open-hearth.

(*b*) Rivet steel, and steel for plates or angles over [$\frac{3}{4}$] $\frac{7}{16}$ in. in thickness which are to be punched, shall be made by the open-hearth process.

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30):[2]

Section 3 (a).—Change to read as follows by the addition of the italicized word:

3. (*a*) The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

Section 10.—Change this section, exclusive of the table of bend test requirements, from its present form: namely,

10. The test specimen shall stand being bent cold around a pin without cracking on the outside of the bent portion, as follows:

to read as follows:

10. The test specimen shall stand being bent cold around a pin without cracking. Bend tests shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

(*a*) Continuous and uniform application of force throughout the duration of the bending operation;

(*b*) Unrestricted movement of the specimen at points of contact with the apparatus;

(*c*) Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failures due to such methods shall not constitute a basis for rejection. The following requirements for degree of bending and sizes of pins shall be observed: (The present table of bend test requirements to be included without change.)

Section 11 (a).—The committee recommends a further change in the tentative revision of this section proposed last year,[3] involving the omission of the so-called machining clause from this section. It is accordingly proposed to change this section from its present form: namely,

11. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 85.

[2] *Ibid.*, p. 131.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1040 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 906.

be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

11. (*a*) Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.

NOTE.—The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel), or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 13.—The committee recommends a further addition, involving the theoretical weight of deformed bars and definition of the term "lot," to the tentative revision of this section, proposed last year. It is proposed to change this section from its present form: namely,

13. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

13. The weight of any lot of bars shall not vary more than 5 per cent over or under the theoretical or specified weight of that lot. The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars ⅜ in. and less. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 - 14):[1]

Section 2.—Change to read as follows by the addition of the italicized words:

2. The bars shall be rolled from standard section Tee rails. *No other materials such as those known by the terms "rerolled," "rail-steel equivalent," and "rail-steel quality" shall be substituted.*

Section 6.—Change this section, exclusive of the table of bend test requirements, from its present form: namely,

6. The test specimen shall stand being bent cold around a pin without cracking on the outside of the bent portion, as follows:

to read as follows:

6. The test specimen shall stand being bent cold around a pin without cracking. Bend tests shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

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[1] **1930 Book of A.S.T.M. Standards, Part I, p. 135.**

(*a*) Continuous and uniform application of force throughout the duration of the bending operation;

(*b*) Unrestricted movement of the specimen at points of contact with the apparatus;

(*c*) Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failures due to such methods shall not constitute a basis for rejection. The following requirements for degree of bending and sizes of pins shall be observed: (The present table of bend test requirements to be included without change.)

Section 7.—The committee recommends a further change in the tentative revision of this section proposed last year,[1] involving the omission of the so-called machining clause from this section. It is accordingly proposed to change this section from its present form: namely,

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

7. (*a*) Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.

NOTE.—The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel), or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 9.—The committee recommends a further addition, involving the theoretical weight of deformed bars and definition of the term "lot," to the tentative revision of this section, proposed last year. It is proposed to change this section from its present form: namely,

9. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

9. The weight of any lot of bars shall not vary more than 5 per cent over or under the theoretical or specified weight of that lot. The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over $\frac{3}{8}$ in. in diameter; nor more than 12.5 per cent over or under for bars $\frac{3}{8}$ in. and less. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 - 27):[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1041 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 907.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 138.

Section 3 (*a*).—Change to read as follows by the addition of the italicized word:

3. (*a*) The steel shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

Standard Specifications for Welded and Seamless Steel Pipe (*A 53 – 30*):[1]

Section 2 (*a*).—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized word:

2. (*a*) The steel for welded pipe shall be soft weldable quality made by the *acid*-bessemer or by the open-hearth process.

Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (*A 83 – 30*):[2]

These specifications have been revised to include a new grade of boiler tube of higher tensile strength than those covered by the present standard specifications. The specifications have also been improved by changes of a minor nature and are accordingly appended hereto[3] in their revised form and recommended for publication as tentative, to supersede when adopted as standard, the present standard specifications.

Standard Specifications for Commercial Quality Hot-Rolled Bar Steels (*A 107 – 30*):[4]

Section 3.—Change this section to read as follows by the addition of the italicized word:

3. The steel shall be made by the open-hearth or *acid*-bessemer process, as specified.

Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (*A 108 – 30*):[5]

Section 3.—Change this section to read as follows by the addition of the italicized words:

3. (*a*) Bar steel shall be made by the open-hearth or *acid*-bessemer process, as specified.

(*b*) Shafting shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (*A 78 – 30*):[6]

Section 3 (*b*).—A further change is recommended in the tentative revision of this section proposed last year,[7] pertaining to the chemical composition when the material is used for fusion welding. It is accordingly proposed to make the footnote referred to in this section a note and to change it to read as follows by the addition of the italicized words:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 245.

[2] *Ibid.*, p. 238.

[3] See p. 549.—ED.

[4] 1930 Book of A.S.T.M. Standards, Part I, p. 140.

[5] *Ibid.*, p. 144.

[6] *Ibid.*, p. 122.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1043 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 909.

NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply, *and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and for chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.*

PROPOSED REVISIONS OF TENTATIVE STANDARDS

Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T):[1]

Section 3 (b).—Make the footnote referred to in this section a note and change it to read as follows by the addition of the italicized words:

NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply *and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and/or chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.*

Tentative Specifications for Soft Steel Track Spikes (A 65 – 26 T):[2]

Section 1.—Change to read as follows by the addition of the italicized word:

1. The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

Section 3.—Add to this section a new Paragraph (*c*) to read as follows:

(*c*) Where ladle analysis cannot be furnished, the manufacturer shall furnish a report of the chemical analysis made on three spikes selected at random from each 10-ton lot.

Tension Tests.—Add the following optional tension test requirements as a new Section 4 under the heading Physical Properties and Tests and renumber the present Sections 4 to 9 accordingly:

4. (*a*) *Tensile Strength.*—The manufacturer may, at his option, substitute tension tests for the chemical analysis specified in Section 2, in which case the finished spikes shall conform to the following minimum requirements as to tensile properties:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 648 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 41.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 631 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 23.

Tensile strength, lb. per sq. in.	55 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent	25

(*b*) When this option is exercised, one tension test shall be made from each 10-ton lot or fraction thereof.

Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T):[1]

Section 2 (a).—Change the first sentence to read as follows by the addition of the italicized word:

> 2. (*a*) The steel for welded pipe shall be soft weldable quality made by the *acid*-bessemer or by the open-hearth process.

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 – 31 T):[2]

Title.—Add the following parenthetical phrase to the title: "(sizes 30 in. and over)."

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the figure in brackets:

> 1. These specifications cover steel pipe ***30 in. in diameter and over***, with a wall thickness up to [$\frac{5}{8}$] *$\frac{3}{4}$* in. inclusive, manufactured by the electric-fusion-welding process.

Section 3.—Change the first sentence of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> The longitudinal edges of the plate shall be [machined to a shape that will] ***shaped to*** give the most satisfactory results in electric-fusion welding.

Section 10 (b).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> (*b*) Diameter.—The outside diameter of the pipe shall be within tolerances consistent with the [method] ***requirements*** of field joints ***as arranged by agreement with the purchaser***. [When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe, and shall permit the passing, for the distance of 8 in., of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 729 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 84.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 673 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 88.

Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 31 T):[1]

A number of minor revisions have been made in these specifications and they are accordingly appended hereto[2] in their revised form and recommended for acceptance as tentative to supersede the present tentative specifications.

Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 31 T):[3]

These specifications have been extensively revised, the revisions consisting of the addition of requirements for chemical properties and tests and the inclusion of physical properties and tests. A number of minor revisions have also been made. The specifications are accordingly appended hereto[4] in their revised form and recommended for acceptance as tentative to supersede the present tentative specifications.

Tentative Specifications for Lock-Bar Steel Pipe (A 137 – 31 T):[5]

Section 3.—In the table of physical requirements for lock bars change the requirement for elastic limit to read as follows by the addition of the italicized words and the omission of those in brackets:

[Elastic limit] *Yeild point,*[a] minimum lb. per sq. in. . . . 0.5 tens. str.

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[a] *Yield point shall be determined by the drop of the beam of the testing machine.*

Section 10.—Renumber the present section as Paragraph (*a*) and add the following as Paragraph (*b*):

(*b*) The edge distance shall be one-half the lap.

Section 12 (a).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

12. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure [that will stress the plate to 20,000 lb. per sq. in.] *calculated from the following formula*, provided, that in no case shall the test pressure exceed 500 lb.:

$$P = \frac{2St}{D}$$

where P = *the hydrostatic pressure in pounds per square inch;*
S = *the allowable fiber stress (maximum 20,000 lb. per sq. in.);*
t = *the wall thickness in inches;*
D = *the outside diameter in inches.*

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 677 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 92.

[2] See p. 570.—Ed.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 683 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 98.

[4] See p. 576.—Ed.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 686 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 101.

Section 16.—Change to read as follows by the addition of the italicized words:

16. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating *in the manner and kind* specified by the purchaser.

Section 17.—Change the last sentence of this section to read as follows by the addition of the italicized words:

Burlap pads *or other approved materials shall be used to prevent injury to the coating and* shall be well secured to prevent shifting in transportation.

Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T):[1]

Section 1.—Change to read as follows by the addition of the italicized words:

1. These specifications cover shop-fabricated straight pipe *suitable for conveying liquids or gases,* made from steel or wrought-iron plates with riveted seams.

Section 3.—Change from its present form: namely,

3. Unless otherwise specified, rivets shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.

to read as follows:

3. Unless otherwise specified, rivets for steel pipe shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials. Unless otherwise specified, rivets for wrought-iron pipe shall be of wrought iron.[a]

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[a] Pending the development by Committee A-2 on Wrought Iron of specifications for wrought-iron rivets, it is recommended that rivet material shall conform to Grade B of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A.S.T.M. Designation: A 84) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part I, p. 435.

Section 5 (b).—Change the last sentence of Paragraph (*b*) to read as follows by the addition of the italicized word and the omission of the words in brackets:

Punched holes shall be spaced true to line, so that when the [plate edges] *plates* are brought together the holes will match properly.

Section 8 (a).—Change the description of S, used in the formula for calculating hydrostatic pressure, from its present form: namely,

S = the allowable fiber stress (maximum 22,000 lb. per sq. in.)

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 691 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 106.

to read as follows:

S = the allowable fiber stress, which shall not exceed 20,000 lb. per sq. in. for steel pipe nor more than 13,000 lb. per sq. in. for wrought-iron pipe.

Change the description of *e*, used in the formula, to read as follows by the addition of the italicized words:

e = the efficiency of the joint, *in accordance with Paragraph U-20 of the Rules for Unfired Pressure Vessels of the A.S.M.E. Boiler Construction Code.*

Section 10.—Change to read as follows by the addition of the italicized words:

10. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating *in the manner and kind* specified by the purchaser.

REPORT OF SECTIONAL COMMITTEE ON STANDARDIZATION OF DIMENSIONS AND MATERIAL OF WROUGHT-IRON AND WROUGHT-STEEL PIPE AND TUBING

This report of the Sectional Committee on Standardization of Wrought-Iron and Wrought-Steel Pipe and Tubing is one of progress only. A preliminary draft of the standard entitled "Proposed Tentative Americar Standard for Wrought-Iron and Wrought-Steel Pipe for Service at Maximum Temperature of 450° F." has been prepared. This proposed tentative standard is developed to cover the entire field of piping work for wrought-iron and wrought-steel pipe from the lowest pressure requiring the use of thin-walled pipe in the larger sizes to pipe sufficiently heavy for the highest pressures now in use, namely, that for 1500 lb. and in all sizes from $\frac{1}{8}$ to 24 in. in nominal outside diameter with the addition of the 30-in. nominal size for thin-walled pipe. Comparison with standard schedules now in use shows that the set-up provides for standard weight pipe, $\frac{1}{8}$ to 12 in. in nominal size and extra-strong pipe, $\frac{1}{8}$ to 10 in. in nominal size. The need for double-extra-strong pipe as now manufactured was not apparent.

Reports received on the preliminary draft of the standard from members of Subcommittee 2 on Pipe and Tubing for Low-Temperature Service and Subcommittee 3 on Pipe and Tubing for High-Temperature Service indicated that the general form and arrangement were satisfactory. It is hoped that the proposed standard can be in shape for general comment of industry and the approval by the sectional committee at an early date.

Subcommittee 3 on Pipe and Tubing for High-Temperature Service has been requested to revise Table I in the Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A.S.T.M. Designation: A 106) of the American Society for Testing Materials to line up to best advantage with present mill practice. When available, the revised table will accompany a revision of the Standard Specifications A 106 now under consideration by Committee A-1 on Steel of the American Society for Testing Materials. The revised table will include a wall thickness schedule for 300-lb. seamless steel pipe and, in general, will conform to the standards being formulated in this sectional committee.

A progress report has been received from Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service of the A.S.T.M. Committee A-1 on Steel regarding the feasibility of drafting specifications and setting values of allowable stress for materials used at temperatures above 750° F. Subcommittee XXII proposes to draft specifications and set allowable stresses for materials suitable for use at temperatures up to 850° F. Allowable stress at 850° F. will be taken as a percentage of that previously established for use at 750° F., the percentage for any particular metal being determined from consideration of its long-time creep characteristics. A curve of suggested percentages covering a range of temperatures was included in the report by way of illustrating the set-up.

Respectfully submitted on behalf of the sectional committee,

H. H. MORGAN,
Chairman.

SABIN CROCKER,
Secretary.

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON

Committee A-2 on Wrought Iron has held one meeting this year at Cleveland, Ohio, on March 8, 1932. A second meeting will be held prior to the presentation of this report to the Society at which time the report will be reviewed and other matters considered.

Recommendations Affecting Standards and Tentative Standards

The following recommendations are made relative to the standards and tentative standards under the jurisdiction of the committee:

Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (*A 138 – 31 T*):[1]

Section 3.—Change from its present form: namely,

> 3. Unless otherwise specified, rivets shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.

to read as follows:

> 3. Unless otherwise specified, rivets for steel pipe shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials. Unless otherwise specified, rivets for wrought-iron pipe shall be of wrought iron.[a]

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[a] Pending the development of specifications for wrought-iron rivets, by Committee A-2 on Wrought Iron, it is recommended that rivet material shall conform to Grade B of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A.S.T.M. Designation: A 84 – 30) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part I, p. 435.

Section 8 (*a*).—Change the description of S, used in the formula for calculating hydrostatic pressure, from its present form: namely,

> S = the allowable fiber stress (maximum 22,000 lb. per sq. in.)

to read as follows:

> S = the allowable fiber stress, which shall not exceed ....[b] lb. per sq. in. for steel pipe nor more than 13,000 lb. per sq. in. for wrought-iron pipe.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 691 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 106.

[b] The value of S for steel pipe is given in the report of Committee A-1 on Steel, see p. 87.

Certain revisions in the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30) and a new definition of the term "double-refined iron" appearing in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A 81 – 30) were accepted as tentative revisions of these standards in 1931.[1] At the March meeting of Committee A-2 it was decided to continue these revisions as tentative until the next publication of the Book of Standards in 1933.

The recommendation appearing in this report has been submitted to letter ballot of the committee with the following results:

Item	Affirmative	Negative	Not Voting
PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T).......	33	0	6

ACTIVITIES OF SUBCOMMITTEES

In the following, the committee discusses other features of its work, in the order of the respective subcommittees responsible for them.

Subcommittee I on Tubes and Pipe (G. H. Woodroffe, chairman).—The revisions in the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 31 T) were prepared and proposed to Committee A-2 by this subcommittee. As these specifications were prepared by Committee A-1 on Steel and provisions for wrought iron incorporated at the request of Committee A-2, the revisions were necessarily submitted to Committee A-1 and accepted at a meeting in Cleveland, Ohio, in March, 1932.

Subcommittee III on Staybolt and Engine-Bolt Iron (E. J. Edwards, chairman).—This subcommittee is engaged in preparing specifications for wrought-iron rivets in accordance with instructions received at the March meeting.

Subcommittee IV on Plates and Sheets (James Aston, chairman).—This subcommittee is being reorganized to include manufacturers, consumers, and fabricators of wrought-iron plates. It will probably be decided also to include representatives of the sheet industry, both producers and consumers.

Subcommittee V on Chain Iron and Iron Chain (F. M. Waring, chairman).—This subcommittee has considered a request submitted by a number of chain manufacturers to incorporate in the Standard Specifications for Iron and Steel Chain (A 56 - 30) a clause to the effect that all hand-made crane chain shall be made of wrought iron, lap-fire welded by a strictly hand-made dollie process and the links formed, scarfed and welded by hand labor. The subcommittee has considered this request and reports that the specifications as now written do not prevent the specifying of a strictly hand-made chain if desired and it can see no advantage in introducing a clause which so definitely limits the process of manufacture. The matter has not been definitely concluded and it is probable that the petitioners will be invited to meet with the subcommittee and present their views on this matter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 1043 and 1050, respectively (1931); also 1931 Book of A.S.T.M. Tentative Standards, pp. 909 and 916, respectively.

Subcommittee X on Research (J. H. Higgins, chairman).—This subcommittee has undertaken the correlation of data and the preparation of a brochure on Quality Standards for Wrought Iron. The active work is under the direction of Mr. James Aston and as the first step in the collection of the data a questionnaire has been sent to each member of Committee A-2. There is an utter lack of authoritative published information on the subject of wrought iron. The members of Committee A-2 representing the leading producing and consuming interests, individually possess data which, if made available, will constitute a work of great value. The questionnaire referred to is classified into topical groups and subdivisions, covering physical properties, chemical analyses, and structural characteristics. It is hoped that frank and full comments will be expressed on all of the points involved. The work when completed will not be in any sense a specification, but merely a guide to users of wrought iron, which it is hoped will help them to determine the quality of the wrought iron they purchase.

A study of the effect of elevated temperatures on the physical properties of wrought iron is also under consideration by this subcommittee in cooperation with the Joint Research Committee on Effect of Temperature on the Properties of Metals of the A.S.M.E. and A.S.T.M. A tentative program limited to an investigation on pipe has been prepared and it was hoped that work could be started this year. Owing to present economic conditions, however, it has been found impossible to obtain the funds necessary and the project has been held in abeyance until conditions improve.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 53 members; 39 members have returned their ballots, of whom 38 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. W. FAUS,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The proposed revision of the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe was accepted. The specifications in their revised form appear on page 586.

REPORT OF COMMITTEE A-3
ON
CAST IRON

Since the 1931 annual meeting of the Society, Committee A-3 on Cast Iron held two meetings, one at Cleveland, Ohio, on March 8, 1932, and the other at Detroit, Mich., on May 3, 1932. A third meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters considered.

Committee A-3 has lost three members by death during the past year. Mr. LaVerne W. Spring was a valuable member for many years, having been active in the formation of Subcommittee XVII on Gray-Iron Castings for Valves, Flanges and Pipe Fittings and chairman of this subcommittee. Mr. Alan F. Hilton was a young metallurgist of considerable promise and helpful in committee work. Mr. S. N. Petrenko had been a member of Subcommittee XV on Impact Testing since the formation of the subcommittee and had done considerable work in the recent investigation of impact testing of cast iron. Committee A-3 has suffered a heavy loss through the passing of these men.

At the March meeting of the committee, it was decided to cooperate with the American Foundrymen's Association in the presentation of a comprehensive symposium on gray-iron castings at the 1933 annual meeting of the American Society for Testing Materials. A joint committee, including representatives from both the A.S.T.M. and the A.F.A., has been appointed to develop this symposium.

Committee A-3 at the May meeting decided to cooperate with the American Foundrymen's Association in the preparation of a program covering discussion of specifications and testing methods for gray cast iron to be presented at the 1933 meeting of the American Foundrymen's Association.

The present membership of the committee is 100, of whom 36 are classified as producers, 42 as consumers and 22 as general interest.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Tentative Standard.—The committee recommends for publication as tentative proposed Tentative Specifications for Cast-Iron Culvert Pipe, as appended hereto,[1] prepared by Subcommittee VIII on Cast-Iron Culvert Pipe.

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[1] See p. 619.—ED.

Proposed Tentative Revision of Standard.—Committee A-3 has recognized that the Standard Specifications for Gray-Iron Castings (A 48 - 29)[1] and the Standard Specifications for High-Test Gray-Iron Castings (A 88 - 31)[2] were inadequate to represent the castings produced by the industry. A year ago Subcommittees VI and XIII were reorganized into a new Subcommittee VI whose function was to classify cast irons and develop specifications. The proposed Tentative Specifications for Gray-Iron Castings, appended hereto,[3] is the result and the committee accordingly recommends that these specifications be published as tentative to supersede when adopted as standard the two standard specifications.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee II on Pipe has been reorganized with considerable increase in membership and with Mr. J. D. Stoddard as chairman. It is expected that the first meeting of this subcommittee will be held during the annual meeting of the Society.

Subcommittee VI on General Castings (J. W. Bolton, chairman) and *Subcommittee XIV on Correlation of Test Bar and Casting* (R. S. MacPherran, chairman) have been very active during the past year in the development of the proposed Tentative Specifications for Gray-Iron Castings being recommended, as appended hereto,[3] to supersede the existing standard specifications A 48 - 29 and A 88 - 31. The committee desires to express its appreciation to the Gray Iron Institute for the cooperation of its representatives in the development of these specifications.

Subcommittee VIII on Cast-Iron Culvert Pipe (E. F. Kelley, chairman).—For several years there have been requests to the Society for specifications for cast-iron culvert pipe. Subcommittee VIII was delegated to develop such specifications. This subcommittee has accordingly been active during the past year and the result of this activity has been the development of the proposed Tentative Specifications for Cast-Iron Culvert Pipe, appended hereto.[4]

Subcommittee X on Nomenclature and Definitions (Robert Job, chairman).—Mr. W. M. Saunders resigned as chairman of this subcommittee and Mr. Robert Job was appointed chairman. It is expected that a meeting of this subcommittee will be held during the annual meeting of the Society.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 494.

[2] 1931 Supplement to Book of A.S.T.M. Standards, p. 19.

[3] See p. 625.—ED.

[4] See p. 619.—ED.

Subcommittee XV on Impact Testing (J. T. MacKenzie, chairman).—This subcommittee has been engaged in an extensive investigation on impact testing of cast iron. It was expected that this work would be completed in time for a presentation of the report at this annual meeting of the Society. Due to delays on the part of some of those cooperating in the investigation, it was decided to delay the presentation of the report until the 1933 annual meeting. It is expected that the report will be issued during the fall of 1932 so that there will be ample time for study so as to develop discussion at the 1933 annual meeting.

Subcommittee XVIII on Automotive Castings (A. L. Boegehold, chairman).—Subcommittee XVIII has issued a questionnaire to producers and consumers of automotive castings and as a result has secured the opinions of the interested parties in reference to tests and specifications on automotive castings. This may result in tentative specifications for automotive castings.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARD			
Tentative Specifications for Cast-Iron Culvert Pipe	44	0	14
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Standard Specifications for Gray-Iron Castings (A 48 – 29)	52	0	6
Standard Specifications for High-Test Gray-Iron Castings (A 88 – 31)	52	0	6

This report has been submitted to letter ballot of the committee which consists of 99 members; 58 members returned their ballots, of whom 57 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

HYMAN BORNSTEIN,
Chairman.

W. H. ROTHER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Cast-Iron Culvert Pipe were accepted for publication as tentative and appear on page 619.

The proposed revision of the Standard Specifications for Gray-Iron Castings and for High-Test Gray-Iron Castings, in the form of new tentative specifications entitled Tentative Specifications for Gray-Iron Castings, was accepted as further revised on the floor of the annual meeting, see Summary of Proceedings, page 23. The tentative specifications in the form as amended appear on page 625.

REPORT OF COMMITTEE A-4
ON
HEAT TREATMENT OF IRON AND STEEL

During the past year the work of Committee A-4 on Heat Treatment of Iron and Steel has been transacted by correspondence and no meetings have been held.

The committee recommends the following proposed revisions of the terms "heat treatment," "annealing," "normalizing" and "tempering," appearing in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 30),[1] for publication as tentative. A definition of the term "nitriding," given below, has also been prepared and is recommended for publication as tentative.

Heat Treatment.—Change the definition of "heat treatment" to read as follows by the addition of the italicized words and the omission of those in brackets:

> Heat Treatment.—An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state *for the purpose of obtaining certain desirable conditions or properties.*
>
> Note.—[This is for the purpose of obtaining certain desirable conditions or properties.] Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of this definition.

Annealing.—Change the definition of "annealing" to read as follows by the addition of the italicized words and the omission of Note 1, shown in brackets, leaving the present Note 2 as the only note under this section:

> Annealing.—A heating and cooling operation of a material in the solid state *and usually implies a relatively slow cooling.*
>
> [Note 1.—Annealing usually implies a relatively slow cooling.]

Normalizing.—Change the definition of "normalizing" to read as follows by the addition of the italicized phrase and sentences and the omission of the sentence in brackets.

> Normalizing.—Heating iron-base alloys *to approximately 100° F.* above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.
>
> Note.—[In the case of hyper-eutectoid steel, it is often desirable to heat above the Ac_{cm} line, as shown in Fig. 2.] *Normalizing is rarely practiced with hyper-eutectoid steels because of the coarsening of the grain and the tendency to*

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 426.

crystallize cementite at grain boundaries or in needles. However, it may sometimes be necessary to normalize these steels by heating them above the Ac_{cm} line of the iron carbon diagram as shown in Fig. 2.

Tempering (also termed Drawing).—Change the definition of "tempering" to read as follows by the addition of the italicized words.

Tempering (also termed Drawing).—Reheating *iron-base alloys* after hardening to some temperature below the critical temperature range followed by any desired rate of cooling.

New Definition.—Add a new definition of the term "nitriding" reading as follows:

Nitriding.—Adding nitrogen to iron-base alloys by heating the metal in contact with ammonia gas or other suitable nitrogenous material.

NOTE.—Nitriding is conducted at a temperature below the iron-carbon critical temperature range and produces surface hardening of the metal without quenching.

The above revisions of the standard definitions were approved by the Joint Committee on Definitions of Terms Relating to Heat Treatment consisting of three representatives of the American Society for Steel Treating, three representatives of the Society of Automotive Engineers and three representatives of the American Society for Testing Materials.

The above recommendation has been referred to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE REVISION OF STANDARD			
Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys) (A 119 – 30)..	31	1	15

This report has been submitted to letter ballot of the committee which consists of 47 members; 26 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. M. BOYLSTON,
Chairman.

J. H. HALL,
Secretary.

EDITORIAL NOTE

The proposed revisions of the definitions of the terms "heat treatment," "annealing," "normalizing," and "tempering," appearing in the Standard Definitions of Terms Relating to Heat Treatment Operations (Especially as Related to Ferrous Alloys), and also the new definition of the term "nitriding," were accepted for publication as tentative and appear on page 985.

REPORT OF COMMITTEE A-5
ON
CORROSION OF IRON AND STEEL

Committee A-5 on Corrosion of Iron and Steel held two meetings during the past year. All of its work has shown substantial progress.

The committee records with deep sorrow the death of Frederick A. Hull on September 16, 1931. Mr. Hull has been intimately identified with the work of the committee for a number of years and has been the chairman of Subcommittee VIII on Field Tests of Metallic Coatings since the initiation of the tests. His passing gives a feeling of deep personal loss to his associates, and the memory of his kindly spirit and companionship will be an inspiration to his friends. Subcommittee VIII, of which the late Mr. Hull was chairman, presented the following resolutions of appreciation and sympathy which were adopted and spread on the minutes of the committee:

> RESOLVED, That Subcommittee VIII of Committee A-5, whose activities had been planned and directed by the late Frederick A. Hull since the inauguration of the subcommittee in 1924, desires to record a sense of deep personal loss in his passing.
>
> The adroitness with which Mr. Hull handled the diverse problems presented by so complex a subject as field tests on metallic coatings is sufficient tribute to his ability as an executive and parliamentarian. His kind and considerate advice, and his companionship endeared him to his associates. It is the hope of the subcommittee that its work may continue as a result of the noble beginning of its projects under his hand and stand as an exhibit of his energy. Therefore be it further
>
> RESOLVED, That this appreciation be spread upon the minutes of this committee for presentation in its report to the Society; and be it also further
>
> RESOLVED, That a copy of this resolution be transmitted to Mrs. Frederick A. Hull whose loss we share.

Subcommittee III on Inspection of the Annapolis Tests (J. H. Gibboney, chairman).—The sheets in this test were inspected by representatives of the committee on October 20, 1931, and March 2, 1932. No new failures were found at the October, 1931, inspection. Two new failures, sheet A 1 (No. 22 gage bessemer steel, Series A), and sheet U 3 (No. 22 gage copper-bearing pure iron, Series B, manufactured by the Allegheny Steel Co.), were found at the March, 1932, inspection. This test location was visited by severe wind storms in February and March of this year which damaged a number of the sheets in racks 2, 3, 5 and 6. The damage to the sheets has been recorded, the racks repaired and all sheets replaced.

Subcommittee V on Total Immersion Tests (F. N. Speller, chairman).—In the report of this subcommittee appended hereto, the study of plate materials and rivets in sea and other water conditions prevalent in shipping service, including some tests in vessel hulls, is making progress. Aside from the important visual observations regularly made and reported upon, replicas are being made of the conditions of plates and rivets at the periods of inspection which, at the completion of the tests, will furnish interesting and important records of the progression of corrosion in the various materials.

Subcommittee VI on Specifications for Metallic-Coated Products (F. F. Farnsworth, chairman).—This subcommittee has completed its study of wire and wire products, and is recommending tentative revisions of the following standards in the form of separate tentative specifications, appended hereto, in which the revisions have been incorporated:

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 30);

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 30);

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 30);

Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 30);

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 30); and

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (A 122 – 30).

It is the feeling of the committee that the revised specifications represent the best thought on quality requirements for the various products, and the specifications are recommended for acceptance as tentative standards to supersede, when adopted as standard, the present specifications. These specifications, if accepted, will be referred to the Sectional Committee on Zinc Coating of Iron and Steel for consideration as American Tentative Standards.

The subcommittee has developed that there is so little commercial demand for specifications for chain-link fence fabric galvanized before weaving that the withdrawal of the Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized Before Weaving (A 118 – 30 T) is recommended.

Subcommittee VII on Methods of Testing (E. S. Taylerson, chairman).—This subcommittee has held two meetings during the year. The research group has made little progress in developing accelerated testing methods which will predict service in the atmosphere. The group working on the revision of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 – 30) has done more experimental work and expects to report at the June meeting. A small group, under the chairmanship of Mr. C. L. Hippensteel, is compiling methods of determining the weight of miscellaneous metallic coatings such as chromium, cadmium, copper and nickel with the cooperation of the electroplating interests. The group studying the Preece test has performed considerable preliminary work and hopes to be able to report on a revision of the present recommendations in the near future. The completion of this work is essential due to its relation to the proposed revisions of the wire specifications being recommended by Subcommittee VI.

Subcommittee VIII on Field Tests of Metallic Coatings (R. F. Passano, chairman).—This subcommittee has continued its investigations on galvanized sheets, making the usual inspections as mentioned in the report appended hereto. These tests indicate at the locations where the coatings have failed, namely, Altoona, Pa., and Brunot Island, Pittsburgh, Pa., that the durability of a zinc coating is substantially proportional to the weight of coating; and further, that the relative resistance to corrosion of zinc and iron varies at different locations, depending on the nature of the impurities in the air.

The tests on coated hardware, structural shapes, tubular goods, etc., have been regularly inspected as shown in the appended report. It may be well to recall that the detailed results which are shown in the 1931 report of the committee should be interpreted in light of the service condition and the wide range in weights of metallic coatings. In view of the extensiveness of the table showing the inspection results it has been decided to prepare it for publication at longer intervals than one year.

The comprehensive field tests on electroplated coatings in cooperation with the American Electro-Platers' Society, as announced last year, have made rapid progress. Some 7000 specimens have been prepared at the U. S. Bureau of Standards, Washington, D. C., and are now exposed on special test racks at Sandy Hook, N. J.; Bell Telephone Laboratories, New York City; Pennsylvania State College, State College, Pa.; Pittsburgh, Pa.; Washington, D. C.; and Key West, Fla. Inspections by a joint committee will be made at frequent intervals, and the results of these exposure and laboratory tests will be announced in future reports of the subcommittee.

The program for wire tests, as prepared by a special committee, has been approved by the subcommittee and will be launched just as soon as the members interested in the information which such tests might develop can find the time to collect and expose specimens at the test locations.

Subcommittee IX on Metal Culvert Tests (H. E. Smith, chairman).—The program for culvert tests has been approved in many important details. The magnitude of the work and the present period of depression have made it necessary to suspend activities temporarily. However, the subcommittee contemplates this project as an important future work.

Subcommittee X on Embrittlement Investigation (V. F. Hammel, chairman).—This subcommittee in its report appended hereto is reporting the completion of its investigations conducted at Battelle Memorial Institute, Columbus, Ohio. The record of the investigation in a report under the title "Embrittlement of Hot-Galvanized Structural Steel"[1] by Samuel Epstein, mentioned as an exhibit to its report, discloses the causes of occasional embrittlement and states that the art is now such that injurious embrittlement can be avoided. This information has made possible the preparation of a guide for safe-guarding against the injurious embrittlement of hot-galvanized steel products, and suggests a method for detecting embrittlement in hot-galvanized structural steel angles.[2] The subcommittee wishes to express its satisfaction in the choice of investigators, and to acknowledge the high order of cooperation that has been offered by Battelle Memorial Institute and its engineers. It wishes also to acknowledge the liberal donations of materials and time on the part of the manufacturers who have cooperated, and the liberal donations of contributing interests, the rolling mills, the fabricators, the Zinc Institute and the National Electric Light Association, and particularly the Utilities Research Commission for its liberal contribution of funds and its active support in combining its project with that of the committee.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

[2] This recommended practice has been accepted for publication as tentative and appears on p. 615. See Editorial Note, p. 104.—ED.

Items	Affirmative	Negative	Not Voting
I. TENTATIVE REVISIONS OF EXISTING STANDARDS			
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Wire (A 111 - 30)	60	0	19
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 - 30)	64	0	16
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 - 30)	57	1	22
Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 - 30)	55	1	24
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 - 30)	58	1	21
Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (A 122 - 30)	62	1	17
II. WITHDRAWAL OF TENTATIVE STANDARD			
Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized Before Weaving (A 118 - 30 T)	52	0	28

This report has been submitted to letter ballot of the committee which consists of 121 members; 83 members returned their ballots, of whom 72 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Chairman.

JAMES ASTON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Wire, for Zinc-Coated (Galvanized) Iron or Steel Tie Wires, for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing, for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving, for Zinc-Coated (Galvanized) Iron or Steel Barb Wire and for Zinc-Coated (Galvanized) Iron or Steel Wire Strand, in the form of new tentative specifications, were accepted for publication as tentative and appear on pages 589 to 614.

The withdrawal of the Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized Before Weaving was approved.

The proposed Tentative Recommended Practice for Safeguarding Against Embrittlement of Hot-Galvanized Structural Steel Products and Procedure for Detecting Embrittlement, as proposed on the floor of the annual meeting, see Summary of Proceedings, page 26, was accepted for publication as tentative and appears on page 615.

TABLE I.—REPORT ON TOTAL

Group	Designation	Series	Description	Average Analysis, per cent					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.380	0.090	0.036		0.017
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.062	0.405	0.100	0.043		0.014
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.075	0.448	0.092	0.035		0.140
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.041	0.372	0.094	0.067	0.010	0.254
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.058	0.370	0.093	0.043		0.266
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.055	0.380	0.111	0.044		0.522
B	Open-Hearth Steel	A	Non-Copper-Bearing	0.023	0.229	0.012	0.052	0.004	0.117
F	Open-Hearth Steel	A	" " "	0.293	0.503	0.026	0.039	0.010	0.038
O	Low-Copper Open-Hearth Steel	A	" " "	0.118	0.522	0.009	0.029	0.223	0.021
Z4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.042	0.318	0.063	0.042		0.019
B	Open-Hearth Steel	A	Copper-Bearing	0.038	0.232	0.009	0.063	0.004	0.167
G	Open-Hearth Steel	A	" "	0.290	0.510	0.027	0.039	0.010	0.241
H	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.076	0.371	0.011	0.028	0.002	0.246
M	Open-Hearth Steel, Alan Wood Steel Co	B	" "	0.097	0.396	0.014	0.043	0.012	0.184
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.078	0.322	0.010	0.020		0.237
Z5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.067	0.351	0.045	0.052		0.187
Z6	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.062	0.388	0.054	0.053		0.275
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.012	0.027	0.003	0.022	0.002	0.021
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.009	0.016	0.007	0.020	0.008	0.022
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.010	0.065	0.007	0.026		0.033
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.025	0.034	0.006	0.039	0.020	0.198
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.016	0.075	0.009	0.034	0.003	0.269
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.012	0.048	0.008	0.020		0.299
K	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.112	0.438	0.090	0.044	0.002	0.231
E	Puddled Iron	A	Copper-Bearing	0.039	0.032	0.114	0.021	0.110	0.241
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.052	0.146	0.021	0.213	0.019
	Total Failures to Date	....	....	.....	.....	.....	.....	.....	.....

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

I.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 1, 1927, IN SEA WATER AT U. S. NAVAL

No. 22 GAGE SHEETS

Average Analysis, per cent					Number of Sheets in Test	Failures															
Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 16, 1928, 381 Days	Apr. 30, 1928, 427 Days	June 4, 1928, 462 Days	July 5, 1928, 493 Days	Sept. 7, 1928, 557 Days	Oct. 8, 1928, 588 Days	Nov. 7, 1928, 618 Days	Dec. 6, 1928, 647 Days	Jan. 7, 1929, 679 Days	Jan. 21, 1929,[a] 693 Days	Mar. 7, 1929, 738 Days	June 6, 1929, 829 Days	July 3, 1929, 856 Days	Aug. 7, 1929, 891 Days	Sept. 6, 1929, 921 Days	Oct. 7, 1929,[a] 952 Days
0.380	0.090	0.036		0.017	6		5					2						20			
0.405	0.100	0.043		0.014	6			1			2			1	1				3		
0.448	0.092	0.035		0.140	6			102		101			101		101, 102, 108						
0.372	0.094	0.067	0.010	0.254	6			6, 21, 23						30					31		
0.370	0.093	0.043		0.266	6										204		202, 202, 204		206		
0.380	0.111	0.044		0.522	6										301				301		
0.229	0.012	0.052	0.004	0.117	3										15						
0.503	0.026	0.039	0.010	0.038	6			10						10					12		
0.522	0.009	0.029	0.223	0.021	6	15, 17		16							9, 28						
0.318	0.063	0.042		0.019	6	418		417, 418, 421											420		
0.232	0.009	0.063	0.004	0.167	3																17
0.510	0.027	0.039	0.010	0.241	6				10											●	
0.371	0.011	0.028	0.002	0.246	6			11							8						
0.396	0.014	0.043	0.012	0.184	6					9									16		11
0.322	0.010	0.020		0.237	6			2													
0.351	0.045	0.052		0.187	6										501				501, 503, 504		
0.388	0.054	0.053		0.275	6			604											605, 606, 606, 607		606
0.027	0.003	0.022	0.002	0.021	6											13				25	
0.016	0.007	0.020	0.008	0.022	6														2		
0.065	0.007	0.026		0.033	6	3						1									
0.034	0.006	0.039	0.020	0.198	6										12						
0.075	0.009	0.034	0.003	0.269	6																
0.048	0.008	0.020		0.299	6							6									
0.438	0.090	0.044	0.002	0.231	6	3	6								27						8
0.032	0.114	0.021	0.110	0.241	6							4							2	12	8
0.052	0.146	0.021	0.213	0.019	6	5		3		1			4		2				6		
					150	6	2	14	1	3	1	4	2	3	14	1	3	1	17	2	5
......	......	......	......	......	....	6	8	22	23	26	27	31	33	36	50	51	54	55	72	74	79

PLATE I.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 32, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS

VAL STATION, KEY WEST, FLA.

ilures on Date of Inspections																									
Oct. 7, 1929,[a] 952 Days	Nov. 7, 1929, 983 Days	Dec. 6, 1929, 1012 Days	Jan. 7, 1930, 1044 Days	Feb. 10, 1930, 1078 Days	Mar. 7, 1930, 1103 Days	Apr. 7, 1930, 1134 Days	May 7, 1930, 1164 Days	June 6, 1930, 1194 Days	July 7, 1930, 1225 Days	Aug. 7, 1930, 1256 Days	Sept. 6, 1930, 1286 Days	Oct. 7, 1930, 1317 Days	Nov. 8, 1930, 1349 Days	Dec. 8, 1930, 1379 Days	Jan. 8, 1931,[a] 1410 Days	Mar. 10, 1931, 1471 Days	Apr. 10, 1931, 1502 Days	May 11, 1931, 1533 Days	June 11, 1931, 1564 Days	July 13, 1931, 1596 Days	Aug. 13, 1931, 1627 Days	Sept. 12, 1931, 1657 Days	Nov. 14, 1931, 1720 Days	Dec. 14, 1931, 1750 Days	Jan. 13, 1932,[a] 1780 Days
	4	2		22			7																		
		303				303		303		9 206			303												
								11				419		29	12						16	12			
17 11 606	2 503		504			20		11 17		10, 11	12 1	13, 20	22, 24	9	14 18	20						19		12	
			18	4			6						8		8	28	23 5			19	17 10				20 17
				6	18				14				20 15		16, 22			24	21				18 27 23	19, 25	8, 10
8	15									30															
8				10			6																		
5	4	2	2	4	1	2	3	4	1	5	2	3	6	2	6	2	2	1	1	1	3	2	3	3	4
79	83	85	87	91	92	94	97	101	102	107	109	112	118	120	126	128	130	131	132	133	136	138	141	144	148

TABLE II.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 7, 19

No. 22 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	Apr. 9, 1928, 399 Days	May 8, 1928, 428 Days	June 13, 1928, 464 Days	Jan. 4, 1929, 669 Days	Mar. 4, 1929, 728 Days	Apr. 6, 1929, 761 Days	May 1, 1929, 786 Days
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper								
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.380	0.094	0.042	0.007	0.012	6							
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.061	0.400	0.114	0.048		0.012	6							
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.071	0.393	0.089	0.045	0.009	0.135	6							108
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.041	0.382	0.098	0.068		0.250	6							
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “	0.050	0.380	0.089	0.037	0.005	0.259	6							
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	“ “	0.041	0.365	0.095	0.045		0.518	6							
B	Open-Hearth Steel	A	Non-Copper-Bearing	0.110	0.380	0.016	0.065	0.013	0.082	4							
F	Open-Hearth Steel	A	“ “ “	0.293	0.503	0.026	0.039	0.010	0.038	6				11			10, 11
O	Low-Copper Open-Hearth Steel	A	“ “ “	0.142	0.545	0.007	0.027	0.217	0.015	6	30			33,34		32, 36	35
Z4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “ “	0.100	0.319	0.069	0.044		0.018	6							
B	Open-Hearth Steel	A	Copper-Bearing	0.090	0.210	0.009	0.060	0.004	0.190	2							
G	Open-Hearth Steel	A	“ “	0.290	0.510	0.027	0.039	0.010	0.241	6			10,11		12		
H	Copper-Bearing Basic Open-Hearth Steel	A	“ “	0.063	0.403	0.017	0.027	0.005	0.245	6	32	38	26	35			29
M	Open-Hearth Steel, Alan Wood Steel Co	B	“ “	0.090	0.400	0.011	0.039		0.187	6			22	29,35	38		33
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	“ “	0.082	0.309	0.009	0.022		0.214	6				39		27	
Z5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “	0.060	0.360	0.047	0.056		0.198	6							509
Z6	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	“ “	0.075	0.390	0.053	0.053	Trace	0.261	6					608		
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.033	0.025	0.004	0.020		0.025	6			33				
S	Low-Copper Pure Iron, American Rolling Mill Co	B	“ “ “	0.016	0.020	0.006	0.023		0.018	6				19			34
X	Low-Copper Pure Iron, Inland Steel Co	B	“ “ “	0.016	0.054	0.006	0.032		0.025	6						22	
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.032	0.025	0.005	0.030	0.006	0.178	6				32			
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	“ “	0.012	0.066	0.008	0.039		0.258	6						38	
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	“ “	0.017	0.048	0.006	0.021		0.302	6						39	
K	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.102	0.455	0.087	0.045		0.238	6							
E	Puddled Iron	A	Copper-Bearing	0.024	0.034	0.111	0.022	0.146	0.297	6							
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.058	0.154	0.020	0.223	0.021	6							
										150	2	1	5	9	3	6	8
	Total Failures to Date										2	3	8	17	20	26	34

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[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

[b] All specimens in the inspection on this date had been sand blasted on April 6, 1931.

PLATE II.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 32, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

7, 1927, IN SEA WATER AT U. S. NAVY YARD, PORTSMOUTH, N. H.

EETS

Failures on Date of Inspections																								
May 1, 1929, 786 Days	June 3, 1929,[a] 819 Days	July 9, 1929, 855 Days	Aug. 7, 1929, 884 Days	Sept. 5, 1929, 913 Days	Oct. 2, 1929, 940 Days	Nov. 4, 1929, 973 Days	Dec. 4, 1929,[a] 1003 Days	Jan. 6, 1930, 1036 Days	Feb. 5, 1930, 1066 Days	Mar. 1, 1930, 1090 Days	April 3, 1930, 1123 Days	May 1, 1930, 1151 Days	May 27, 1930,[a] 1177 Days	July 30, 1930, 1241 Days	Aug. 22, 1930, 1264 Days	Sept. 11, 1930, 1284 Days	Oct. 15, 1930,[a] 1318 Days	Jan. 5, 1931, 1400 Days	Feb. 5, 1931, 1431 Days	Mar. 5, 1931, 1459 Days	June 5, 1931,[b] 1490 Days	Group		
108						4	35 6	5	11	41	39 3 109, 109, 112		28			43 7	111, 113			45		A Z Z1	1189.3 1080.8 1131.8	1134 Days
				207	306	33 213		308	36	39, 42 214	207	43		45 209	310	306		310	208 314			I Z2 Z3	1101.8 1128.5 1225.8	1152.1 Days
10, 11 35	30 424, 421					32, 38 422	36 10 423				12 424		422			12						B F 0 Z4	942.0 941.8 674.2 985.7	880.8 Days
29 33 509	36			25 26 25	506 609	23 608	41 506	28	10 508		11 508	12	41	509	609		608	609				B G H M T Z5 Z6	943.0 832.7 653.8 704.8 866.8 1026.5 1103.8	868.9 Days
34	42	40		21	37 25	31 30 30	41	32	36 35	33			39									D S X	842.3 891.2 1017.2	916.9 Days
	28 33		22			24 29, 31 30	35 27, 37	40	34 42				30				33					C U V	931.3 927.5 1020.7	959.8 Days
							33, 39		36								46		42		48	K	1218.5	1218.5 Days
			16	14		36	13, 22						20									E	992.2	992.2 Days
	8					6	7, 8, 9				7											Y	987.3	987.3 Days
8	8	1	2	6	5	17	18	5	9	5	11	2	6	3	2	4	5	2	3	1	1			
34	42	43	45	51	56	73	91	96	105	110	121	123	129	132	134	138	143	145	148	149	150			

REPORT OF SUBCOMMITTEE V ON TOTAL IMMERSION TESTS

Sea Water Immersion Tests:

The No. 22 gage sheets exposed March 1, 1927, in sea water, at U. S. Naval Station, Key West, Fla., showed, up to March, 1932, a total of 148 failures out of 150 sheets originally in the test. A detailed record of the failures is given in Table I (Plate I). At Portsmouth, N. H., where the No. 22 gage sheets were exposed, March 7, 1927, in sea water at U. S. Navy Yard, all sheets have now failed. The detailed record of failures is given in Table II (Plate II). In view of the completion of the No. 22 gage sheet tests at Portsmouth, N. H., attention is called to the final report on the No. 22 gage sheets and the No. 16 gage sheets exposed at Annapolis made in 1926[1] and 1930,[2] respectively. The final reports on the No. 22 gage sheets and on the No. 16 gage sheets in the immersion tests at Washington, D. C., were made in 1924[3] and 1928,[4] respectively.

The No. 16 gage sheets exposed at Key West, Fla., March 1, 1927, showed a total of 22 failures out of 138 sheets in the test up to March, 1932, as shown in Table III. At Portsmouth, N. H., 18 failures have occurred up to March, 1932, as shown in Table IV.

It was the sense of the subcommittee at its meeting on March 9, 1932, that no official conclusion should be drawn from the salt water immersion tests until the failures of all of the No. 16 gage specimens.

The copper steel pipe immersed in sea water at Key West, Fla., March 1, 1927, and at Portsmouth, N. H., March 7, 1927, have been inspected monthly along with the inspection of the sheet tests. This procedure will be continued. A report as to relative corrosion of these pipes with varying amounts of copper cannot be made at present.

The riveted plates installed July 26, 1926, at Port Arthur, Tex., were cleaned and copper replicas made according to the method previously adopted by the committee.[5] The accompanying photographs, Figs. 1, 2 and 3 illustrate the condition of each sample plate. Table V gives the composition of the plates and rivets.

The committee reports progress in connection with riveted plate tests installed at Key West, Fla., September 27, 1926, and Portsmouth, N. H., July 16, 1926. No definite conclusions can be drawn as yet. Wax impressions have been made recently by the Navy

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 129 (1926).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 223 (1930).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 226 (1924).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 160 (1928).

[5] E. S. Taylerson, "Method of Making Copper Replicas of Corroded Metal Objects," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 234 (1929).

TABLE III.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 1, 1927, IN SEA WATER AT U. S. NAVAL STATION, KEY WEST, FLA.

No. 16 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	Failures on Date of Inspections								
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Sept. 6, 1929, 921 Days	Oct. 7, 1929,[a] 952 Days	Nov. 7, 1929, 983 Days	June 6, 1930, 1194 Days	Sept. 6, 1930, 1286 Days	Jan. 8, 1931,[a] 1410 Days	Mar. 10, 1931, 1471 Days	Jan. 13, 1932,[a] 1780 Days	Feb. 12, 1932, 1810 Days
AA	Bessemer Steel	A	Non-Copper-Bearing	0.030	0.420	0.085	0.040	0.003	0.012	6								1, 13	
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0 080	0.440	0.080	0.032		0.014	6		1							
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.060	0.360	0.091	0.066	0.005	0.254	6									
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.078	0.340	0.091	0.036		0.287	6								201	
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.058	0.359	0.022	0.049	0.005	0.109	6									
FF	Open-Hearth Steel	A	" " "	0.280	0.500	0.027	0.038	0.010	0.034	6								11	10
OO	Low-Copper Open-Hearth Steel	A	" " "	0.110	0.360	0.008	0.029	trace	0.026	6			3			13			
MM	Open-Hearth Steel, Alan Wood Steel Co	B	" " "	0.111	0.400	0.010	0.028	0.011	0.053	6							2		
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.033	6	418				417			417, 419	
GG	Open-Hearth Steel	A	Copper-Bearing	0.290	0.510	0.028	0.039	0.010	0.217	6									
HH	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.069	0.371	0.010	0.026	0.004	0.248	6									
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.087	0.330	0.009	0.019	0.008	0.239	6									
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.075	0.390	0.070	0.073		0.257	6								501	
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.027	0.005	0.033	0.003	0.078	6									
DD	Low-Copper Pure Iron	A	" " "	0.019	0.025	0.004	0.027	0.003	0.028	6				24					32
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.015	0.021	0.006	0.020	0.005	0.023	6		6				21			
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.028	0.060	0.009	0.028	0.006	0.030	6		13	11						
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.028	0.005	0.032	0.006	0.262	6									
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.014	0.075	0.006	0.028	0.007	0.250	6									
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.009	0.050	0.008	0.018		0.288	6									
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.100	0.460	0.085	0.039		0.230	6								3	
EE	Puddled Iron	A	Copper-Bearing	0.033	0.026	0.111	0.019	0.109	0.307	6									
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.124	0.019	0.210	0.021	6						1			
										138	1	3	2	1	1	3	1	8	2
	Total Failures to Date	...	...	...	...	...	...	...	...	...	1	4	6	7	8	11	12	20	22

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

TABLE IV.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 7, 1927, IN SEA WATER AT U. S. NAVY YARD, PORTSMOUTH, N. H.

No. 16 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	Failures on Date of Inspection											
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Dec. 4, 1929,[a] 1003 Days	Feb. 5, 1930, 1066 Days	Mar. 1, 1930, 1090 Days	May 1, 1930, 1151 Days	Jan. 5, 1931,[b] 1400 Days	Feb. 5, 1931, 1431 Days	Aug. 6, 1931,[c] 1616 Days	Sept. 5, 1931, 1646 Days	Oct. 5, 1931, 1676 Days	Dec. 5, 1931, 1737 Days	Jan. 5, 1932, 1768 Days	Feb. 5, 1932, 1799 Days
AA	Bessemer Steel	A	Non-Copper-Bearing	0.053	0.420	0.087	0.041		0.013	6												
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	“ “ “	0.078	0.412	0.100	0.038		0.013	6												
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.057	0.390	0.098	0.066		0.247	6												
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	“ “	0.088	0.317	0.092	0.045	0.000	0.276	6												
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.063	0.338	0.030	0.057	0.078	0.122	6										39		
FF	Open-Hearth Steel	A	“ “ “	0.277	0.500	0.027	0.038	0.010	0.034	6									10			
OO	Low-Copper Open-Hearth Steel	A	“ “ “	0.117	0.377	0.010	0.027	0.005	0.030	6			15					33			32	35
MM	Open-Hearth Steel, Alan Wood Steel Co.	B	“ “ “	0.105	0.420	0.011	0.032	0.005	0.052	6												
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	“ “ “	0.028	0.392	0.042	0.029		0.028	6						420					422	
GG	Open-Hearth Steel	A	Copper-Bearing	0.293	0.506	0.028	0.039	0.010	0.217	6												
HH	Copper-Bearing Basic Open-Hearth Steel	A	“ “	0.073	0.372	0.015	0.027		0.228	6		32										
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	“ “	0.076	0.305	0.010	0.020		0.226	6							21					
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	“ “	0.066	0.373	0.056	0.066		0.227	6												
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.031	0.004	0.033		0.065	6				18								
DD	Low-Copper Pure Iron	A	“ “ “	0.020	0.034	0.004	0.026		0.028	6	50			35						52		
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	“ “ “	0.014	0.017	0.006	0.023		0.028	6												
XX	Low-Copper Pure Iron, Inland Steel Co.	B	“ “ “	0.019	0.053	0.008	0.031		0.027	6											15	
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.027	0.005	0.027	0.005	0.221	6												
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	“ “	0.013	0.066	0.010	0.033		0.243	6												
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	“ “	0.016	0.033	0.007	0.022		0.289	6												
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.120	0.418	0.085	0.042		0.240	6												
EE	Puddled Iron	A	Copper-Bearing	0.030	0.040	0.124	0.018	0.130	0.334	6										15		
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	Non-Copper-Bearing	0.030	0.052	0.123	0.018	0.193	0.024	6					7				8			
										138	1	1	1	2	1	1	1	1	2	3	3	1
	Total Failures to Date	....	....	....	....	....	....	....	....	....	1	2	3	5	6	7	8	9	11	14	17	18

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.
[b] All specimens in the inspection on this date had been sand blasted on May 27, 1930, and October 15, 1930.
[c] All specimens in the inspection on this date had been sand blasted on April 6, 1931.

Department of the riveted plate tests at both these locations from which copper replicas will be made.

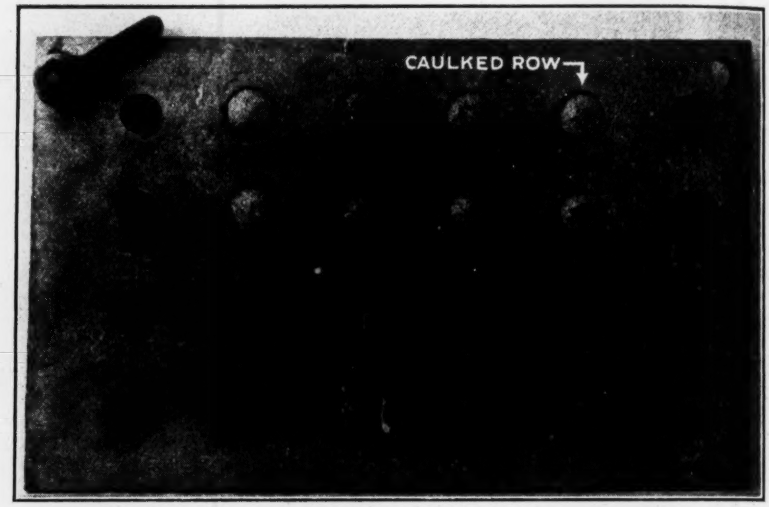

FIG. 1.—Replica of Low-Copper Plate, Rivet Point Side After Sand Blasting, from Port Arthur, Tex., November 4, 1931.

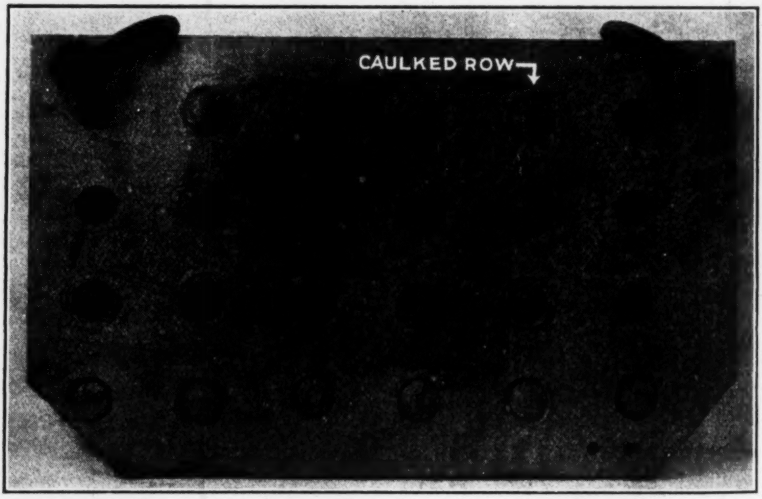

FIG. 2.—Replica of High-Copper Plate, Rivet Point Side After Sand Blasting, from Port Arthur, Tex., November 4, 1931.

Rivet Tests in Ships:

Mr. James French of Lloyds' Register of Shipping, who is supervising the tests of rivets and plates in oil tankers, reports that an examination in March, 1931, showed considerable corrosion on the outside of the rivets in the S. S. "New York." There has been no opportunity for further inspection of these ship tests. A number of rivets have been renewed. Interesting conclusions may be expected on completion of these tests.

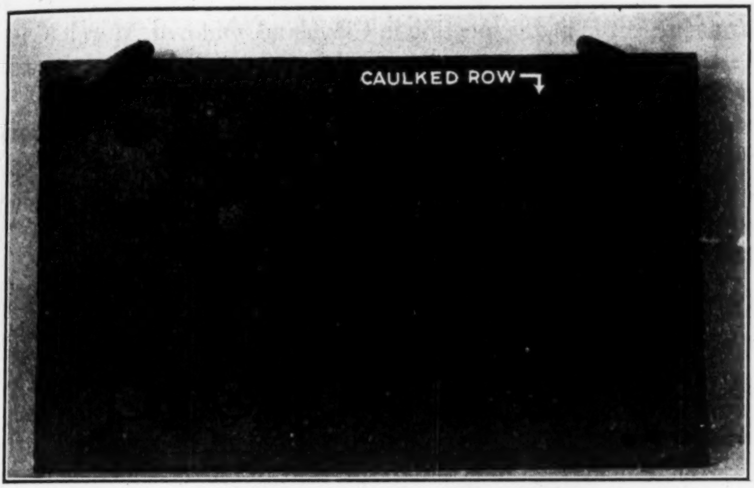

FIG. 3.—Replica of High-Silicon Plate, Rivet Point Side After Sand Blasting, from Port Arthur, Tex., November 4, 1931.

TABLE V.—CHEMICAL COMPOSITIONS OF RIVETS AND PLATES IN THE RIVETED TESTS.

	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent
Top Row: Low-Copper Steel Rivets....	0.08	0.32	0.010	0.026	0.01	0.07
Second Row: High-Copper Steel Rivets.	0.11	0.48	0.008	0.029	0.01	0.27
Third Row: Low-Copper Puddled Iron Rivets..........................	0.08	0.02	0.115	0.010	0.10	0.02
Bottom Row: Ship-Quality Steel Rivets	0.20	0.45	0.022	0.039	0.01	0.03
One hole in lower corner[a] indicates low-copper plates....................	0.21	0.42	0.015	0.036	0.02	0.04
Two holes in lower corner[b] indicate high-copper plates....................	0.15	0.34	0.023	0.034	0.01	0.23
Three holes in lower corner[c] indicate high-silicon plates................	0.34	0.58	0.015	0.024	0.19	0.03

[a] See Fig. 1. [b] See Fig. 2. [c] See Fig. 3.

At the March meeting of this subcommittee, Mr. F. B. Olcott was elected chairman for the ensuing term of two years.

This report was considered by the subcommittee at its meeting in Cleveland, Ohio, on March 9, 1932, and was unanimously approved.

Respectfully submitted on behalf of the subcommittee,

F. N. SPELLER,
Chairman.

REPORT OF SUBCOMMITTEE VI ON SPECIFICATIONS FOR METALLIC-COATED PRODUCTS

This report covers the work of Subcommittee VI for the past year as presented at the meeting in Cleveland, Ohio, on March 8, 1932. The subcommittee is presenting revisions in six standard specifications which are recommended for publication as tentative. The revisions are quite extensive and have accordingly been incorporated in separate proposed tentative specifications, appended hereto.[1]

The following digest notes the essential changes in substance contained in the proposed revisions of the present standard specifications for galvanized wire and wire products.

General Changes Common To All Specifications:

1. All specifications have been made as self-contained as possible in order that reference to other specifications may be reduced to a minimum.

2. Weight and dip class designation for characterizing coatings has been eliminated and weight of coating requirements specified separately from uniformity requirements. Where reference is made to the Preece test, it is specifically stated "This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to weight of coating requirements."

3. In so far as possible, coated wire is referred to as "galvanized wire," and each table specifically labeled as referring to "uncoated" or "galvanized" wire.

4. Where comments have indicated it to be desirable, inspection requirements have been reworded to clarify the meaning of the section.

Specific Changes in Individual Specifications:[2]

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 30):[3]

Section 9:[2] *Adherence of Coating.*—A requirement for adherence of coating has been included in the revised specifications, which was given as optional in a note in A 111 – 30.

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[1] See pp. 589 to 614.—Ed.

[2] Section numbers refer to the revised tentative specifications appended hereto, see pp. 589 to 614.—Ed.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 294.

Section 13: Resistivity.—The resistivity values for copper-bearing steel have been added and the new table of resistivities reads as follows:

TABLE II.—RESISTIVITY, LB. PER MILE-OHM

	GRADE EBB		GRADE BB		GRADE STEEL	
	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM
Copper-bearing.............	5000	5200	5600	5800	6500	6800
Non-copper-bearing.........	4800	5000	5400	5600	6300	6600

The values given as average in the table shall not be exceeded by the average of all results determined for the lot of wire. Individual samples may have resistivities not exceeding the values given as maximum.

Section 14 (d): Gaging.—The new requirements provide for the rejection of any coil if the gage at any point is not within specified limits, whereas, under the old requirement, a coil should be rejected if the average gage were outside specified limits.

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 30):[1]

Section 3 (b): Base Metal.—A requirement covering copper-bearing steel similar to that for line wire has been added.

Section 4: Joints.—A requirement has been added as follows:

4. There shall be no joints in tie wires.

Section 9: Adherence of Coating.—An adherence requirement has been added as follows:

9. (*a*) The zinc coating shall remain adherent when the tie wire is wrapped at a rate of not more than 15 turns per minute in a closed helix at least twice about a cylindrical mandrel having a diameter equivalent to the nominal diameter of the tie wire under test.

(*b*) The zinc coating shall adhere firmly to the wire and shall be considered as meeting this requirement if, due to wrapping about the mandrel, it does not flake and none of the coating can be removed from the wire by rubbing with the bare fingers.

Section 12: Twists.—The following twist requirement has been added:

12. The galvanized tie wires shall withstand without fracture not less than 35 twists in a length equivalent to 100 diameters. This test shall be made in a standard torsion machine or equivalent, with one head of the machine rotating and the opposite head non-rotating but movable horizontally. The weight on the movable head shall be 15 lb., and the rate of rotation 35 twists in 2 minutes.

Section 16: Finish.—For clarity, a statement has been added as follows: "The ends of the tie wires need not be galvanized."

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 299.

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 30):[1]

Sections 7 and 9: Weight and Uniformity of Coating.—No changes have been made in the weight and uniformity of coating requirements for railroad right-of-way wire fencing. Both weight and uniformity requirements for farm-field wire fencing have been reduced, as shown below, to give a truer picture of present commercial practice:

Nominal Diameter of Galvanized Wire, in.	Size, Steel Wire Gage	Old Weight Oz. per Sq. Ft.	New Weight Oz. per Sq. Ft.	Old Dips	New Dips
0.192	6	0.5	0.40	3	2½
0.177	7	0.5	0.40	3	2½
0.162	8	0.5	0.40	3	2½
0.148	9	0.5	0.40	3	2½
0.135	10	0.35	0.30	2	1½
0.120	11	0.35	0.30	2	1½
0.105	12	0.35	0.30	2	1½
0.098	12½	0.35	0.30	2	1½

NOTE.—For the sake of brevity, the above table shows changes in both weight and uniformity requirements.

Section 11: Packing and Marking.—The requirement concerning marking now reads as follows: "Each roll of fencing shall carry a tag legibly marked as specified by the purchaser."

Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 30):[2]

Section 2: Size and Mesh.—The nominal diameter and gage size for *uncoated* wires are specified as differentiated from other wire specifications where galvanized wire sizes are given.

Section 10: Uniformity of Coating.—The Preece test requirements for this class of material have been increased from 4 dips of 1 minute each to 5 dips of 1 minute each.

Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 30):[3]

Section 7: Weight of Coating.—In line with present commercial practice, weight of coating requirements for the three sizes of wire specified have been reduced from 0.35 oz., minimum, per square foot of uncoated wire to 0.3 oz.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 302.

[2] *Ibid.*, p. 305.

[3] *Ibid.*, p. 308.

Section 9: Uniformity of Coating.—Preece test requirements have been correspondingly reduced from 2 dips to 1½ dips.

Standard Specifications for Zinc-Coated (Galvanized) Steel Wire Strand (A 122 - 30):[1]

Section 4: Joints.—The following section has been added:

4. (*a*) There shall be no strand joints or strand splices in any length of the completed strand unless specifically permitted by the purchaser.

The individual wires composing the strand shall, preferably, be of continuous length without factory joints. However, joints in individual wires are acceptable provided there be no more than one joint in any 150-ft. section of the completed strand and the location of each wire joint be marked on the strand with paint or some other distinguishing mark.

(*b*) Joints in the wires composing the strand shall be either the brazed-lap type or butt-welded type. When the brazed type of joint is used, the length of the lap shall be not less than three times the diameter of the wire and the over-lapping faces shall be smooth, clean, properly fluxed and completely covered by the brazing metal. When the butt-welded type of joint is used, care shall be taken to prevent injury to the wire by reason of overheating. All joints shall be well made and shall be galvanized after completion.

Section 5: Stranding.—The following section on stranding has been added to replace the old Section 6 on "Lay of Strand:"

5. Unless otherwise specified, 7-wire strand shall have a left-hand lay with a uniform pitch not less than twelve nor more than sixteen times the nominal diameter of the strand. In the case of 19- and 37-wire strand, the outer layer of wires shall be left-hand lay. A left-hand lay is defined as a counter-clockwise twist away from the observer. All wires shall be stranded with uniform tension. Stranding shall be sufficiently close to insure no appreciable reduction in diameter when tested to 10 per cent of the specified strength.

Section 7: Weight of Coating.—No changes in weight and uniformity of coating requirements covering "extra-galvanized" or "double-galvanized" strand have been made.

The requirements for weight of coating of "galvanized" common strand have been reduced in accordance with present practice. It is felt that this material is largely used for temporary construction projects and that more severe requirements are not justified. Changes in the weight of coating requirements are as follows:

Sizes 0.145 to 0.207 in., inclusive, 0.40 oz. per sq. in. of uncoated wire surface, instead of 0.5 oz. per sq. in.

Sizes 0.080 to 0.120 in., inclusive, 0.30 oz. per sq. in. of uncoated wire surface, instead of 0.35 oz. per sq. in.

Sizes 0.041 to 0.072 in., inclusive, no change.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 311.

Section 9: Uniformity of Coating.—Preece test requirements for the various sizes of wire have been reduced as follows for "galvanized" common strand:

NOMINAL DIAMETER OF GALVANIZED WIRES IN THE STRAND, IN.	OLD PREECE TEST REQUIREMENTS, DIPS	NEW PREECE TEST REQUIREMENTS, DIPS
0.207	3	2½
0.188	3	2½
0.165	3	2½
0.145	3	2½
0.125	2	1½
0.104	2	1½
0.093	2	1½
0.080	2	1½
0.072	1	1
0.062	1	1
0.052	1	½
0.041	1	½

Section 10: Ductility of Steel and Adherence of Coating.—The following section has been added:

> 10. The ductility of the steel in the wires of the completed strand and the adherence of the zinc coating on the wires shall be determined by wrapping individual wires at the rate of not more than 15 turns per minute, in a closed helix at least twice around a cylindrical mandrel of a diameter equal to three times the nominal diameter of the individual wire for Common strand, five times for Siemens-Martin, and six times for High Strength and Extra-High Strength. The wires shall withstand this test without fracture, and the zinc coating shall adhere firmly to the wire without flaking and without being removable by rubbing with the bare fingers.

Section 15: Marking.—A requirement covering the marking of the finished coils or reels of strand has been added as follows:

> Each coil or reel shall bear a strong tag securely fastened to it showing the length, size and grade of the strand, and the manufacturer's name or mark.

Tentative specifications of similar titles to the above six standards are appended hereto.[1] These specifications have been approved by the subcommittee by substantial unanimous vote, and it is the hope that the publication of these tentative standards will facilitate consideration of them by the Sectional Committee on Specifications for Zinc Coating of Iron and Steel in order that their submission to the American Standards Association for approval can be recommended at the earliest possible date.

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[1] See pp. 589 to 614.—ED.

It was decided at the March meeting, subject to confirmation by letter ballot of the subcommittee, to withdraw the Tentative Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized Before Weaving (A 118 - 30 T).[1] The subcommittee has been unable to obtain any comment on these specifications during their publication as tentative, and it is felt that there is so little demand for this type of product that the Society will not wish to establish standard specifications for it.

The subcommittee can report no progress on the development of specifications for plated coatings on iron and steel. The preparation of specifications for such coatings will be considered as the need becomes apparent from the cooperative studies now being made by Subcommittee VIII on Field Tests of Metallic Coatings, and the Research Committee of the American Electro-Platers' Society.

The present chairman was reelected for the ensuing term of two years.

This report was considered by the subcommittee at its meeting in Cleveland, Ohio, on March 8, 1932, and was unanimously approved.

Respectfully submitted on behalf of the subcommittee,

F. F. FARNSWORTH,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 973 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 109.

REPORT OF SUBCOMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

Subcommittee VIII held one general meeting during the year. Reports of progress on the three investigations which are now under way, and the status of the program of tests on wire are given below.

Galvanized Sheets

A Special Committee on Inspection of Galvanized Sheets under the chairmanship of Mr. M. E. McDonnell has made several inspections during the year.

The special committee made four inspections during the year of the tests at Altoona and Brunot Island and two at State College and Sandy Hook, while Mr. William Blum, of the National Bureau of Standards and a member of Subcommittee VIII, made one inspection of the Key West tests for the inspection committee.

The sheets on the Altoona, Pa., test rack were inspected on April 21, July 20, and October 20, 1931, and on January 29, 1932. The sheets on the test rack at Brunot Island, Pittsburgh, Pa., were inspected on April 20, July 20, and October 19, 1931, and on January 29, 1932. Inspections were made at State College, Pa., on April 21 and October 20, 1931, and at Sandy Hook, N. J., on April 22 and October 21, 1931. The Key West, Fla., tests were inspected on March 1, 1932.

Since the last annual report, corrosion has progressed at all of the test locations, and there have been some additional failures of coatings, as well as of base metal. All of the coating failures to date have occurred at Altoona, Brunot Island and Sandy Hook and are recorded in Tables I, II, and III.

In the Altoona tests, Table I, all 2.50-oz. coatings on the No. 16 gage sheets have now failed with an average life of 4.37 years. There is one (out of 18) 2.50-oz. coating on a No. 22 gage sheet which has not yet failed.

It is to be noted from Table II that all 2.50-oz. coatings on the No. 16 gage sheets at Brunot Island have now failed with an average life of 5.18 years, while only 12 (out of 18) of the 2.50-oz. coatings on the No. 22 gage sheets have failed. All of the lighter coatings had failed at the time of the last report, the durability of the coating having been substantially proportional to the weight of the coating.

At Sandy Hook, Table III, none of the 1.50, 2.00, and 2.50-oz. coatings have yet failed. Only one 1.25-oz. coating has failed, but

TABLE I.—RECORD OF COATING FAILURES ON ALTOONA, PA., TEST RACK. SHEETS EXPOSED APRIL 22, 1926.

Description	Number of Samples in Test	Apr. 7, 1927, 0.96 year	Sept. 28, 1927, 1.43 years	May 1, 1928, 2.03 years	July 27. 1928, 2.27 years	Oct. 30, 1928, 2.53 years	Jan. 28, 1929, 2.77 years	Apr. 23, 1929, 3.00 years	July 23, 1929, 3.25 years	Oct. 29, 1929, 3.52 years	Feb. 10, 1930, 3.81 years	Apr. 22, 1930, 4.00 years	July 28, 1930, 4.27 years	Oct. 29, 1930, 4.52 years	Feb. 3, 1931, 4.79 years	Apr. 21, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 20, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.....	10	none	none	none	none	none	none	none	none	none	none	none	7	2	1	..	..	..	..	10	4.37
No. 22 Gage, 2.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	1	2	none	1	5	2	2	none	2	1	1	17	(4.56)[a]
No. 22 Gage, 2.00 oz. per sq. ft.....	18	none	none	none	none	none	none	none	6	4	none	none	8	..	..	..	..	..	..	18	3.76
No. 22 Gage, 1.50 oz. per sq. ft.....	18	none	none	none	2	4	none	1	11	..	..	..	..	..	..	..	..	..	..	18	2.97
No. 22 Gage, 1.25 oz. per sq. ft.....	18	none	none	none	13	3	none	1	1	..	..	..	..	..	..	..	..	..	..	18	2.41
No. 22 Gage, 0.75 oz. per sq. ft.....	14	none	6	1	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	1.89
No. 28 Gage, 0.75 oz. per sq. ft.....	10	none	1	3	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2.11
	106	none	7	4	28	7	none	2	19	6	none	1	20	4	3	none	2	1	1		
Total Failures to Date.........	......	none	7	11	39	46	46	48	67	73	73	74	94	98	101	101	103	104	105	105	

[a] Figures shown in parentheses are not to be considered as final.

TABLE II.—RECORD OF COATING FAILURES ON BRUNOT ISLAND, PITTSBURGH, PA., TEST RACK. SHEETS EXPOSED APRIL 21, 1926.

Description	Number of Samples in Test	Apr. 6, 1927, 0.96 year	Sept. 27. 1927, 1.43 years	Apr. 30, 1928, 2.03 years	July 26, 1928, 2.27 years	Oct. 29, 1928, 2.53 years	Jan. 29, 1929, 2.78 years	Apr. 22, 1929, 3.00 years	July 22, 1929, 3.25 years	Oct. 28, 1929, 3.52 years	Feb. 11, 1930, 3.81 years	Apr. 21, 1930, 4.00 years	July 27, 1930, 4.27 years	Oct. 30, 1930, 4.52 years	Feb. 4, 1931, 4.79 years	Apr. 20, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 19, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.....	12	none	none	none	none	none	none	none	none	none	none	none	1	none	2	1	4	3	1	12	5.18
No. 22 Gage, 2.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	none	none	none	1	1	1	none	none	4	4	1	12	(5.42)[a]
No. 22 Gage, 2.00 oz. per sq. ft....	18	none	none	none	none	none	none	none	none	1	none	2	3	6	3	none	1	none	2	18	4.59
No. 22 Gage, 1.50 oz. per sq. ft.....	18	none	none	none	none	none	none	none	10	3	3	1	1	..	..	..	..	..	..	18	3.49
No. 22 Gage, 1.25 oz. per sq. ft.....	18	none	none	none	none	2	none	none	16	..	..	..	..	..	..	..	..	..	..	18	3.17
No. 22 Gage, 0.75 oz. per sq. ft.....	14	none	none	5	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	2.18
No. 28 Gage, 0.75 oz. per sq. ft.....	10	none	none	2	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2.22
	108	none	none	7	17	2	none	none	26	4	3	4	6	7	5	1	9	7	4		
Total Failures to Date.........	......	none	none	7	24	26	26	26	52	56	59	63	69	76	81	82	91	98	102	102	

[a] Figures shown in parentheses are not to be considered as final.

13 of the 14 samples of 0.75-oz. coatings have failed on the No. 22 gage sheets as have also 9 of the 10 samples of 0.75-oz. coatings on the No. 28 gage sheets.

At State College none of the coatings have failed after 5½ years' exposure. Approximately 85 per cent of the No. 22 gage, 0.75-oz. coated sheets are now showing a yellowed condition, while only 20 per cent of the No. 28 gage, 0.75-oz. coatings showed yellowed areas. One-third of the No. 22 gage, 1.25-oz. coatings showed slightly yellowed areas. One-sixth of the No. 22 gage, 1.50-oz. coated sheets showed traces of this condition. None of the 2.00 or 2.50-oz. coated sheets on this test rack showed indications of yellowing.

TABLE III.—RECORD OF COATING FAILURES ON SANDY HOOK, N. J., TEST RACK. SHEETS EXPOSED MAY 20, 1926.

Description	Number of Samples in Test	April 24, 1930 3.93 years	Oct. 30, 1930, 4.45 years	April 22, 1931, 4.93 years	Oct. 21, 1931, 5.42 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.	10	none	none	none	none	none	..
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	..
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	..
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	none	..
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	none	1	1	..
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	10	1	2	13	(4.73)[a]
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	6	1	2	9	(4.84)[a]
	106	none	16	2	5	..	
Total Failures to Date	......	none	16	18	23	23	

[a] Figures shown in parentheses are not to be considered as final.

At Key West no failures of coatings have as yet occurred. The basic carbonate coating which forms at this location evidently has considerable protective value. Yellowed areas are beginning to show on these sheets.

The tests to date indicate at places where coatings have failed, namely, Altoona and Brunot Island, that the durability of a zinc coating is substantially proportional to the weight of the coating. The durability of zinc coatings is less in locations where the atmosphere is contaminated with impurities that convert the zinc coating into soluble salts than in locations where the air is pure or where a protective film is formed.

At Altoona and Brunot Island the zinc coating is now entirely gone from the upper surface of the majority of the test sheets. The appearance of these sheets is now similar to that of black, uncoated sheets, and there is a marked difference in the texture and adherence of the oxide coatings, which are coarse and loose on some sheets and fine and adherent on others. In this respect, they seem to be analogous to the black sheet test previously reported by Subcommittee III.[1] This difference will receive further consideration in future inspections and reports of the committee. While the undersides of the sheets are generally yellowed at Altoona and Brunot Island, the actual failure of coatings on the underside is at the bottom edge, due to water being drawn back on the underside by capillary attraction. This condition is conducive to a ragged-edge failure of the sheet at the lower end, which may be aggravated due to the fact that all of the ends of the sheets were sheared after coating.

Bend Specimens.—While the bend tests have been inspected at regular stated intervals, the committee does not feel justified in making a report at this time other than to state that the light coatings have not shown good durability, notwithstanding the fact that they did not flake on bending, and this condition will be covered in greater detail when the base metal of the different bend test specimens has failed at the bend.

TABLE IV.—TIME IN YEARS FOR PERFORATIONS OF NO. 22 GAGE, BLACK SHEETS.[a]

Identification	Class of Material	Average Chemical Composition									Brunot Island, Pittsburgh, Pa.	Altoona, Pa.	Key West, Fla.	Sandy Hook, N. J.	State College, Pa.
		Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent					
R	Open-Hearth Iron.......	0.011	0.021	0.004	0.018	0.004	0.032	0.023	[d]	0.004[b]	2.03	4.27	3.62	—	—
V	Open-Hearth Iron.......	0.018	0.053	0.005	0.032	0.004	0.051	0.045	[d]	0.007[b]	2.27	4.27	3.62	4.93	—
U	Open-Hearth Iron.......	0.015	0.020	0.004	0.024	0.005	0.087	0.106	[d]	0.009[b]	2.53	4.27	3.62	5.42	—
N	Open-Hearth Iron.......	0.013	0.057	0.007	0.029	0.003	0.167	0.057	[d]	0.004[b]	3.00	—	3.62	—	—
T	Open-Hearth Iron.......	0.016	0.157	0.007	0.028	0.004	0.228	0.073	[d]	0.004[b]	—	—	3.62	—	—
Y	Open-Hearth Steel......	0.028	0.346	0.067	0.050	0.005	0.029	0.003[b]	0.013	[c]	2.03	2.03	2.62	3.45	—
S	Open-Hearth Steel......	0.040	0.488	0.072	0.041	0.003	0.051	0.006[b]	0.094	[c]	3.25	—	3.62	—	—
C	Open-Hearth Steel......	0.066	0.458	0.053	0.045	0.003	0.222	0.003[b]	0.000[b]	[c]	—	—	5.73	—	—
K	Open-Hearth Steel......	0.023	0.460	0.066	0.045	0.003	0.268	0.023[b]	0.031	[c]	—	—	4.58	—	—
W	Wrought Iron...........	0.021	0.048	0.143	0.019	0.210	0.025	0.020[b]	[d]	0.003[b]	3.00	5.00	3.62	4.93	—

[a] Blanks in table represent sheets that have not failed as yet. The material has been under observation for 5¾ years.
[b] Average of determinations in one laboratory.
[c] Less than 0.003 per cent; results of one laboratory.
[d] Less than 0.006 per cent; results of one laboratory.

Uncoated Sheets.—The black, uncoated sheets have received careful attention, and up to the present time seven of ten sheets at Brunot Island, five of ten at Altoona, four of ten at Sandy Hook, all ten sheets at Key West, and none at State College have failed. These tests show conclusively that the relative resistance to corrosion of zinc and iron varies at different locations, depending on the nature of the impurities in the air.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 18, Part I, p. 180 (1918).

During the past year all of the fifty uncoated sheets which have been exposed at the five locations have been analyzed at the laboratories of the American Rolling Mill Co. and the American Sheet and Tin Plate Co. The results were in excellent agreement and the

TABLE V.—ANALYSES OF BLACK, UNCOATED SHEETS EXPOSED AT PITTSBURGH, ALTOONA, SANDY HOOK, STATE COLLEGE AND KEY WEST.[a]

Identification	Class of Material	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent
RB	Open-Hearth Iron	0.011	0.022	0.003	0.019	0.004	0.030	0.024	[c]	0.007[b]
RK	Open-Hearth Iron	0.011	0.019	0.004	0.018	0.004	0.032	0.024	[c]	0.003[b]
RX	Open-Hearth Iron	0.010	0.022	0.004	0.019	0.004	0.033	0.021	[c]	0.003[b]
RZ	Open-Hearth Iron	0.011	0.021	0.005	0.017	0.003	0.032	0.023	[c]	0.003[b]
VA	Open-Hearth Iron	0.016	0.055	0.005	0.031	0.003	0.051	0.046	[c]	0.007[b]
VB	Open-Hearth Iron	0.018	0.055	0.005	0.031	0.004	0.051	0.045	[c]	0.007[b]
VC	Open-Hearth Iron	0.019	0.052	0.005	0.032	0.004	0.054	0.043	[c]	0.007[b]
VE	Open-Hearth Iron	0.018	0.051	0.005	0.032	0.004	0.047	0.046	[c]	0.007[b]
UB	Open-Hearth Iron	0.015	0.019	0.002	0.023	0.005	0.086	0.105	[c]	0.013[b]
UL	Open-Hearth Iron	0.015	0.019	0.004	0.023	0.004	0.081	0.106	[c]	0.013[b]
US	Open-Hearth Iron	0.016	0.020	0.004	0.024	0.005	0.087	0.106	[c]	0.007[b]
UV	Open-Hearth Iron	0.014	0.021	0.004	0.027	0.005	0.089	0.107	[c]	0.007[b]
UX	Open-Hearth Iron	0.015	0.022	0.004	0.024	0.005	0.090	0.106	[c]	0.007[b]
NB	Copper-Bearing Open-Hearth Iron	0.011	0.054	0.007	0.030	0.003	0.169	0.057	[c]	0.007[b]
NE	Copper-Bearing Open-Hearth Iron	0.016	0.058	0.006	0.026	0.003	0.165	0.057	[c]	0.003[b]
NH	Copper-Bearing Open-Hearth Iron	0.012	0.057	0.007	0.029	0.003	0.165	0.057	[c]	0.003[b]
NK	Copper-Bearing Open-Hearth Iron	0.011	0.058	0.008	0.028	0.003	0.168	0.056	[c]	0.003[b]
TB	Copper-Bearing Open-Hearth Iron	0.015	0.15	0.007	0.026	0.003	0.228	0.074	[c]	0.003[b]
TL	Copper-Bearing Open-Hearth Iron	0.018	0.17	0.008	0.033	0.003	0.243	0.073	[c]	0.003[b]
TN	Copper-Bearing Open-Hearth Iron	0.015	0.16	0.007	0.028	0.004	0.216	0.073	[c]	0.007[b]
TV	Copper-Bearing Open-Hearth Iron	0.017	0.16	0.007	0.026	0.004	0.226	0.072	[c]	0.003[b]
TZ	Copper-Bearing Open-Hearth Iron	0.014	0.16	0.008	0.028	0.004	0.227	0.073	[c]	0.003[b]
YH	Open-Hearth Steel	0.024	0.34	0.062	0.045	0.004	0.027	0.002[b]	0.012	0.003[b]
YV	Open-Hearth Steel	0.028	0.34	0.068	0.051	0.004	0.028	0.004[b]	0.013	[d]
YW	Open-Hearth Steel	0.029	0.35	0.069	0.051	0.005	0.028	0.002[b]	0.014	0.003[b]
YZ	Open-Hearth Steel	0.030	0.35	0.069	0.052	0.005	0.031	0.002[b]	0.013	[d]
SC	Open-Hearth Steel	0.047	0.49	0.070	0.040	0.003	0.049	0.007[b]	0.091	[d]
SN	Open-Hearth Steel	0.051	0.49	0.072	0.042	0.003	0.051	0.007[b]	0.096	[d]
SS	Open-Hearth Steel	0.041	0.49	0.075	0.042	0.003	0.050	0.007[b]	0.098	[d]
SU	Open-Hearth Steel	0.023	0.48	0.068	0.039	0.003	0.051	0.005[b]	0.095	[d]
SX	Open-Hearth Steel	0.039	0.49	0.076	0.042	0.003	0.053	0.006[b]	0.091	0.003[b]
CB	Copper-Bearing Open-Hearth Steel	0.068	0.45	0.054	0.048	0.004	0.226	0.003[b]	[c]	0.003[b]
CL	Copper-Bearing Open-Hearth Steel	0.062	0.45	0.049	0.042	0.003	0.220	0.002[b]	[c]	0.003[b]
CM	Copper-Bearing Open-Hearth Steel	0.063	0.46	0.053	0.044	0.003	0.224	0.002[b]	[c]	[d]
CT	Copper-Bearing Open-Hearth Steel	0.062	0.47	0.050	0.042	0.003	0.216	0.005[b]	[c]	[d]
CU	Copper-Bearing Open-Hearth Steel	0.073	0.47	0.059	0.047	0.003	0.222	0.002[b]	[c]	[d]
KA	Copper-Bearing Open-Hearth Steel	0.023	0.46	0.070	0.048	0.003	0.273	0.025[b]	0.033	[d]
KN	Copper-Bearing Open-Hearth Steel	0.030	0.47	0.070	0.048	0.003	0.271	0.025[b]	0.027	[d]
KS	Copper-Bearing Open-Hearth Steel	0.021	0.48	0.069	0.048	0.003	0.271	0.020[b]	0.030	[d]
KV	Copper-Bearing Open-Hearth Steel	0.019	0.43	0.053	0.037	0.003	0.257	0.022[b]	0.030	[d]
KX	Copper-Bearing Open-Hearth Steel	0.024	0.47	0.070	0.046	0.003	0.270	0.023[b]	0.037	[d]
WA	Wrought Iron	0.021	0.049	0.143	0.018	0.216	0.024	0.018[b]	[c]	0.003[b]
WB	Wrought Iron	0.021	0.050	0.145	0.019	0.210	0.024	0.022[b]	[c]	0.003[b]
WH	Wrought Iron	0.023	0.048	0.147	0.018	0.213	0.024	0.021[b]	[c]	0.003[b]
WK	Wrought Iron	0.026	0.043	0.136	0.018	0.194	0.024	0.022[b]	[c]	[d]
WL	Wrought Iron	0.015	0.051	0.146	0.020	0.217	0.027	0.019[b]	[c]	0.007[b]

[a] Results are averages of two laboratories except those indicated otherwise.
[b] Results of one laboratory.
[c] Less than 0.006 per cent; results of one laboratory.
[d] Less than 0.003 per cent; results of one laboratory.

average analysis for each sheet is given in Table V. The average analysis for each of the different kinds of black sheets is shown in Table IV along with the life of each kind at each locality. The composition of the base metal sheets is substantially in accord with the specifications agreed to by the committee when the test was planned.

HARDWARE, STRUCTURAL SHAPES, TUBULAR GOODS, ETC.

A Special Committee on the Inspection of Hardware, Structural Shapes, etc., under the chairmanship of Mr. W. L. Maucher, has made several inspections during the year.

The specimens on the test rack at Brunot Island, Pittsburgh, Pa., were inspected on April 20 and October 19, 1931. Inspections were made at Altoona, Pa., and State College, Pa., on April 21 and October 20, 1931. The specimens at Sandy Hook, N. J., were inspected on April 22 and October 21, 1931.

Due to the inability of any member of this Inspection Committee to go to Key West, Mr. William Blum, of the Bureau of Standards and a member of Subcommittee VIII who has charge of the field tests on electroplated coatings, inspected the specimens at this location.

The first complete tabulation of results was given in the 1931 annual report[1] of this committee. There have been very few additional failures noted at any of the locations since then. In view of the extensiveness of this tabulation, it is deemed advisable to prepare it for publication at longer intervals than one year.

ELECTROPLATED COATINGS

All specimens in this investigation were prepared at the Bureau of Standards with the cooperation of the American Electro-Platers' Society and the manufacturers, and are exposed in these field tests through cooperation with this Society.

The exposure tests were started in the spring of 1932 at Sandy Hook, N. J.; Bell Telephone Laboratories, New York City; Pennsylvania State College, State College, Pa.; Pittsburgh, Pa.; Washington, D. C.; and Key West, Fla. Five 4 by 6-in. specimens of each kind are exposed at each location. These samples will be inspected at regular intervals by members of the Joint Committee consisting of: William Blum, chairman, A. K. Graham, Jacob Hay, R. F. Passano, W. M. Phillips, L. H. Rovere, and Philip Sievering.

Notices of these inspection trips will be sent to the cooperating firms and to others who request the chairman for such notices. Interested persons may be present at these inspections, with the understanding that they will not use any information obtained at that time for publication or for advertising purposes.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 181 (1931).

Corresponding samples will be subjected to laboratory tests, including accelerated corrosion, to determine the relation of these results to atmospheric exposures. The results of these exposure and laboratory tests will not be published until definite conclusions can be reached by the Joint Committee.

In general, a certain arbitrarily selected "standard" procedure for cleaning and plating was employed as a basis of reference, without any implication that such a procedure is necessarily superior. Some important step in the process was then varied over sufficiently wide limits to determine whether such a change produces a definite effect upon the protective value of the coatings. The samples are steel finished with nickel, chromium, zinc, or cadmium, with or without intermediate coatings.

This report will not attempt to cover the plating conditions in detail at this time, since those persons who are working on this project have received the information in mimeographed form and such detailed descriptions will probably be published in the *Monthly Review* of the American Electro-Platers' Society.

The cleaning methods selected were such as to produce thoroughly cleaned surfaces without any attempt to promote them as commercial operations. The plating operations were designed to produce coatings of thicknesses and general characteristics similar to present commercial operations. The thicknesses varied from 0.00013 to 0.002 in. and cover quite a variation in the amounts and kinds of metals used in composite coatings.

The program involves the plating of about 7000 panels, the inspection of the portion which has been exposed at the localities mentioned above, and certain other tests which will be conducted at the Bureau of Standards on the remainder. It is considered that this comprehensive program will consume two or more years of effort on the part of the representatives of the interested technical societies and the Bureau of Standards.

WIRE TESTS

A special committee, under the chairmanship of W. H. Finkeldey, has prepared a program for tests on wire and wire products. This proposed program was approved by letter ballot of the subcommittee. Unfortunately, this is not an advantageous time to collect and expose specimens. It is almost essential that a representative of large users of galvanized wire be found who is sufficiently interested in the results to see that the specimens are collected, exposed, and inspected at suitable intervals. The telephone and telegraph interests have conducted their own investigations, and it is likely therefore that the need for this test will develop through the requirements of the railway companies and farming interests. A special committee has been appointed to develop the extent of the consumers' desire for the information which such tests might develop.

During the past year Mr. F. A. Hull, who was chairman of this subcommittee for eight years, died suddenly. The hours which Mr. Hull spent in the activities of this subcommittee were happy ones and there was a genuine feeling of appreciation for his conduct and friendly touch, both in the Society work and elsewhere. It is with profound regret that we must take note of his absence, yet he will always remain a member of this group in the minds of those who knew him. In accordance with these feelings, the subcommittee has included a resolution in the report of Committee A-5.

At the March meeting of this subcommittee, the undersigned was elected chairman for the ensuing term of two years.

This report was considered by the subcommittee at its meeting in Cleveland, Ohio, on March 9, 1932, and was unanimously approved.

Respectfully submitted on behalf of the subcommittee,

R. F. PASSANO,
Chairman.

REPORT OF SUBCOMMITTEE X ON EMBRITTLEMENT INVESTIGATION

In line with the recommendations of Subcommittee X in its progress report[1] last year, the Steering Committee planned the continuation of the project on embrittlement investigation for another year. The Utilities Research Commission joined with the Society, and Battelle Memorial Institute, Columbus, Ohio, was again retained in July, 1931, as investigator to continue the work on an intensive scale.

It is the belief of the subcommittee that the investigation has disclosed the causes of occasional embrittlement and that the knowledge acquired is now such that injurious embrittlement can be avoided. Consequently, the Steering Committee in conjunction with the staff of the Battelle Memorial Institute has prepared certain recommendations[2] for the revision of the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation: A 123 – 30).[3] These specifications as adopted in 1930, prepared by the Sectional Committee on Specifications for Zinc Coating of Iron and Steel under the procedure of the American Standards Association, were phrased to require that galvanized products be not embrittled. An explanatory note therein states that the ways of avoiding embrittlement are not understood. The subcommittee is proposing, as appended hereto, a guide for safeguarding against the injurious embrittlement of hot-galvanized structural steel products and a recommended practice for detecting embrittlement of hot-galvanized steel angles.[4]

The record of the investigation in the form of a report by the investigators, Battelle Memorial Institute of Columbus, Ohio, under the title "Embrittlement of Hot-Galvanized Structural Steel" by Samuel Epstein constitutes an exhibit to this report.[5]

The present chairman and secretary were reelected for the ensuing term of two years.

This report was considered by the subcommittee at its meeting at Atlantic City, N. J., on June 23, 1932, and was unanimously approved.

Respectfully submitted on behalf of the subcommittee,

V. F. Hammel,
Chairman.

C. S. Trewin,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 211 (1931).

[2] See p. 125.—Ed.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 284.

[4] See p. 615.—Ed.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

RECOMMENDATIONS TO A.S.A. SECTIONAL COMMITTEE ON ZINC COATING OF IRON AND STEEL

RELATING TO STANDARD SPECIFICATIONS FOR ZINC (HOT-GALVANIZED) COATINGS ON STRUCTURAL STEEL SHAPES, PLATES AND BARS AND THEIR PRODUCTS (A 123 – 30)

The following correlative changes are recommended in the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation: A 123 – 30) of the American Society for Testing Materials:[1]

Section 5 (*a*).—Insert the word "injuriously" before the word "embrittled." Strike out "(Note 3)."

Section 7 (*a*).—Change "(Note 4)" to read "(Note 3)."

Section 9.—Change "(Note 5)" to read "(Note 4)."

Section 11.—Change "(Note 6)" to read "(Note 5)."

Explanatory Notes.—Strike out the entire Note 3 and renumber the remaining notes accordingly.

Subcommittee X offers the Tentative Recommended Practice for Safeguarding Against Embrittlement of Hot-Galvanized Structural Steel Products and Procedure for Detecting Embrittlement,[2] appended hereto, and recommends it for publication by the sponsor Society as tentative for eliciting criticism. The committee will continue the investigation in order to collect information on the freedom of the intermediate size shapes to injurious embrittlement; on the susceptibility to serious embrittlement of other open-hearth steels; on the necessity of reducing the gage length for testing intermediate shapes with small holes; on the necessity of measuring reduction in thickness in testing angles; and on a procedure for detecting injurious embrittlement of cold-worked steel plates and bars and their products commonly called hardware.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 284.

[2] The Society has accepted this recommended practice for publication as tentative, see p. 615.—ED.

REPORT OF SECTIONAL COMMITTEE

ON

ZINC COATING OF IRON AND STEEL

The Sectional Committee on Zinc Coating of Iron and Steel has held one meeting during the year, at Cleveland, Ohio, on March 10, 1932, during the spring group meetings of committees of the American Society for Testing Materials.

Technical Committee I on Hardware and Fastenings (A. L. Fox, chairman).—At the time of the last annual report of the sectional committee, Technical Committee I had practically completed its laboratory investigations of commercial coatings on hot-dipped galvanized commercial products classed as hardware and fastenings and had prepared a draft of specifications intended to cover the requirements for a good commercial quality of coating on such articles.

During the past year the chairman of Technical Committee I has been engaged through correspondence and by conferences in New York City and Pittsburgh, Pa., in trying to reconcile certain divergent views as to what requirements should be established in the specifications. It does not appear, however, that this can be entirely accomplished and it is, therefore, planned to spread before the committee members in a report by the chairman these divergent views and refer the matter to the committee for a decision.

Technical Committee II on Sheets and Sheet Products (G. A. Reinhardt, chairman).—This technical committee has no work pending since the adoption of the Standard Specifications for Zinc-Coated (Galvanized) Sheets (A 93 – 27) by the sectional committee and their approval as "American Tentative Standard" by the American Standards Association.

Technical Committee III on Plates, Bars, Structural Shapes and Their Products (V. F. Hammel, chairman).—The report of this technical committee consists of a progress report on the steel embrittlement investigation. Funds have been collected and the work of Subcommittee X on Embrittlement Investigation of Committee A-5 on Corrosion of Iron and Steel of the American Society for Testing Materials has been combined with the project undertaken by the Utilities Research Commission at the Battelle Memorial Institute, Columbus, Ohio. Also, the investigation has resulted in the preparation of a guide for safeguarding against the injurious embrittlement of hot-galvanized structural steel products, and a recommended practice for detecting embrittlement of hot-galvanized steel angles has been developed.[1] The record of the investigation is being presented in the form of a report by the investigators, Battelle Memorial Institute, under the title "Embrittlement of Hot-Galvanized Structural Steel" by Samuel Epstein.[2] Technical Committee III may make the necessary changes in its Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation: A 123) to be referred subsequently to the sectional committee. If approved this will form an amendment to the specifications. It is desired that these revisions be approved by Committee A-5; in the meantime Technical Committee III plans to proceed in giving consideration to the revisions looking toward a modification of the specifications by the sectional committee.

Technical Committee IV on Pipes and Their Fittings (C. J. Krieger, chairman).—The Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T) were approved by this technical committee and subsequently referred to letter ballot in the sectional committee. However, the specifications failed to receive the 90 per cent affirmative vote which is required by the regulations of the sectional committee for approval when voted upon by letter ballot. Since the canvassing of this letter ballot in the sectional committee, discussions have been held regarding the objections raised by those who voted negatively. Revised specifications will soon be offered for further discussion. If approved in Technical Committee IV, these revised specifications will be circulated in the sectional committee for letter ballot.

Technical Committee V on Wire and Wire Products (J. L. Schueler, chairman).—Six A.S.T.M. specifications for galvanized wire products[3] have been circulated in this technical committee for letter ballot. The vote is not yet complete but so far no objections have been raised regarding major points.

Technical Committee VII on Methods of Testing (E. S. Taylerson, chairman).—This technical committee has held two meetings during the year at which the reports of its subcommittees have been considered.

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[1] The Society has accepted this recommended practice for publication as tentative, see p. 615.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

[3] These specifications, prepared by Committee A-5 on Corrosion of Iron and Steel, have been accepted for publication as tentative, see pp. 589 to 614.—ED.

The Research Subcommittee has made little progress in developing satisfactory accelerated testing methods which will predict service in the atmosphere.

A subcommittee working on the revision of the A.S.T.M. Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 - 30) has done more experimental work and expects to report at the June meeting.

The committee studying the Preece test has performed considerable preliminary work and hopes to report on a revision of the present work in the near future. The completion of this work is essential due to its relation to the proposed revisions of the specifications for galvanized wire and wire products mentioned above.

Some changes have been necessary in the personnel of the sectional committee and in the personnel of the various technical committees during the past year. The representation in regard to producers and consumers remains approximately as it was originally.

The present officers were reelected to serve during the coming two years.

Respectfully submitted on behalf of the sectional committee,

J. A. CAPP,
Chairman.

A. B. CAMPBELL,
Secretary.

REPORT OF COMMITTEE A-6

ON

MAGNETIC PROPERTIES

One meeting of Committee A-6 on Magnetic Properties was held during the last year in March in Cleveland, Ohio, in connection with the Spring Group Meeting of A.S.T.M. Committees.

The most important activity of the committee during the year consisted in a complete revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 28). The present standard methods resulted from a gradual growth and alteration, and it was felt that they could be very considerably improved. The proposed changes are in general a modification in arrangement, a substitution of more accurate definitions for the principal magnetic terms used in magnetic testing, and more complete recommendations with reference to the accuracy and suitability of various types of available magnetic testing equipment. The revised methods appended hereto[1] are recommended for publication as tentative to supersede when adopted the present Standard Methods A 34 - 28.

There has been considerable discussion of new definitions of magnetic terms, but no definite action has been taken since the previous report.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Definitions and Nomenclature (W. J. Shackelton, chairman).—No meeting of this subcommittee was held during the year, but at the suggestion of the chairman it was agreed that no further action should be taken at the present time on the list of standard definitions pending action by the Sectional Committee on Definitions of Electrical Terms, functioning under the procedure of the American Standards Association, with which close contact is being maintained.

Subcommittee II on Alternating Current Tests at Low Inductions (R. L. Sanford, chairman).—This subcommittee recommends no modification of the procedure for alternating-current tests at low inductions proposed last year as a tentative revision[2] of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 28) until further experiments have been completed and additional data accumulated. It was urged that members of the committee set up apparatus and report on the results obtained. So far the methods appear to be satisfactory and it is not anticipated that any appreciable changes will be suggested in the immediate future. The procedure for test at low inductions has been incorporated as Sections 12 to 20 in the Tentative Methods appended hereto.[1]

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[1] See p. 650.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1271 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 783.

Subcommittee III on Tests at High Magnetizing Forces (L. E. Howard, chairman).—This subcommittee has made substantial progress in studying the fundamental problems and difficulties associated with determining the magnetic properties of materials at high magnetizing forces. As a result of certain findings of the subcommittee, alterations have been made in the methods of test and incorporated in the revised methods appended hereto.[1]

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Tentative Revision of Standard.—The committee recommends that the Tentative Methods of Test for Magnetic Properties of Iron and Steel, appended hereto,[1] be accepted for publication as a tentative revision of, to supersede when adopted, the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28).[2]

The present incumbents have been reelected for the ensuing term of two years.

The recommendation appearing in this report has been submitted to letter ballot of the committee with the following results:

Item	Affirmative	Negative	Not Voting
I. TENTATIVE REVISION OF EXISTING STANDARD			
Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 28)........	14	0	2

This report has been submitted to letter ballot of the committee which consists of 16 members; 14 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The proposed revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel, in the form of new tentative methods, was accepted for publication as tentative and appears on page 650.

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[1] See p. 650.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 396.

REPORT OF COMMITTEE A-7
ON
MALLEABLE IRON CASTINGS

Committee A-7 on Malleable Iron Castings held four meetings since the presentation of its annual report in 1930, at Atlantic City, N. J., in June, 1930; at Pittsburgh, Pa., in March, 1931; at Chicago, Ill., in June, 1931; and at Cleveland, Ohio, in March, 1932.

At the Chicago meeting the annual report for 1931 was withdrawn to permit changing the specifications for malleable iron castings before asking acceptance by the Society. In order that the revised specifications be given wide distribution and placed before the Society for acceptance at the 1932 annual meeting, the Executive Committee was requested to publish the specifications as recommended by Committee A-7 at the Chicago meeting. This request was granted and the proposed revised Specifications for Malleable Iron Castings, appended hereto,[1] are herewith offered for publication by the Society as tentative. The proposed specifications are the result of a demand for a revision of the Standard Specifications for Malleable Castings (A 47 – 30).[2] The requirements for a higher strength malleable casting among railroads in particular and the uniform grade of castings now being produced by the malleable iron industry were the governing arguments presented to the committee for the revisions as recommended. A recommendation from the Malleable Iron Committee of the American Foundrymen's Association for a revision of Specifications A 47 – 30 was also presented to the committee. This recommendation has been favorably acted on and incorporated in the proposed specifications appended hereto.[1]

The proposed specifications differ from the present standard specifications in that they cover two grades of castings designated by numbers of five digits, namely, grades Nos. 32510 and 35018. The first three digits of the grade number indicate the yield point requirement in hundreds of pounds per square inch and the remaining two digits indicate the percentage of elongation. Grade No. 32510 is identical with the requirements of the present Standard Specifications A 47 – 30, and a new grade No. 35018 covering castings of higher strength is being added. A requirement that the castings shall be free from primary graphite has also been added to the proposed specifications, and the yield point has been defined as "that load under which the specimen has an elongation in 2 in. of 0.01 in."

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[1] See p. 633.—Ed.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 491.

The proposed specifications have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
NEW TENTATIVE STANDARD			
Tentative Specifications for Malleable Iron Castings:[a]			
Grade No. 32510	24	7	5
Grade No. 35018	26	5	5

[a] The classified vote on the Tentative Specifications for Malleable Iron Castings was as follows:
For Grade No. 32510. Affirmative: 12 producers, 8 consumers, 4 general interests; negative: 7 producers, 0 consumers, 0 general interest; not voting: 1 producer, 3 consumers, 1 general interest.
For Grade No. 35018. Affirmative: 15 producers, 7 consumers, 4 general interests; negative: 4 producers, 1 consumer, 0 general interest; not voting: 1 producer, 3 consumers, 1 general interest.

COMMITTEE ACTIVITIES

Two very active members of the committee have been lost through death, namely, Mr. Richard Moldenke and Mr. L. W. Spring. Mr. Moldenke was a member of the committee for many years, and in his passing the members have lost a true friend. His knowledge, patience and kindly spirit contributed much to the success of the committee's work. Mr. Spring was active and agressive in all his assignments, and in his passing our members have lost a true friend and a valued counselor.

Mr. H. W. Maack of Crane Co. has been appointed to fill the vacancy occasioned by the death of Mr. Spring. Mr. F. H. Morehead of the Walworth Co. has been added to the committee roster.

A subcommittee appointed to draft specifications for malleable iron fittings, valves and valve parts has been developing a specification to cover two grades of metal (1) for cupola metal and (2) for air-furnace, electric-furnace and open-hearth metal.

The special committee appointed at the Atlantic City meeting in June, 1930, to investigate the desirability of adopting a lower strength malleable iron specification for some types of castings where machineability is the governing requirement, reported that the demand for such a specification does not exist. This committee also reported that the Society of Automotive Engineers would doubtless adopt as their standard, grade No. 32510 of the proposed Tentative Specifications for Malleable Iron Castings, appended hereto.

There has been considerable interest in the corrosion-resisting properties of malleable iron, especially for overhead trolley construction. This subject is being given further study by a subcommittee now working on the problem which is developing data that promises interesting results.

A subcommittee is studying the problem of galvanizing embrittlement as related to malleable iron castings. This group is making progress in the research necessary for a correct solution of the phenomenon of galvanizing embrittlement in malleable cast iron.

Committee A-7 cooperated with the Malleable Iron Committee of the American Foundrymen's Association in developing a Symposium on Malleable Iron Castings[1] held at the 1931 annual meeting of the Society in Chicago. The result of this cooperation has been the collection of authoritative physical, mechanical, electrical, and chemical data for publication.

At the Cleveland meeting the present incumbents were reelected for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 39 members; 39 members returned their ballots, of whom 28 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

W. P. PUTNAM,
Chairman.

ENRIQUE TOUCEDA,
Secretary.

EDITORIAL NOTE

The proposed revision of the Standard Specifications for Malleable Castings, in the form of new tentative specifications entitled Tentative Specifications for Malleable Iron Castings, was accepted for publication as tentative and appears on page 633.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 317 (1931).

REPORT OF COMMITTEE A-9

ON

FERRO-ALLOYS

Committee A-9 on Ferro-Alloys has not held a meeting since that held at Chicago, Ill. during the 1931 annual meeting of the Society. The committee plans to meet prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters considered.

The committee is recommending for publication as tentative, as appended hereto,[1] the following proposed tentative specifications and proposed tentative methods of chemical analysis:

Proposed Tentative Specifications for Ferro-Tungsten;

Proposed Tentative Specifications for Low-Carbon Ferro-Molybdenum;

Proposed Tentative Specifications for Molybdenum Salts and Compounds;

Proposed Tentative Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum, to be incorporated, when adopted as standard, in the present Standard Methods of Chemical Analysis of Ferro-Alloys (A 104 – 27).[2]

The three proposed specifications being submitted for publication as tentative were prepared by Committee A-9 due to a need for specifications for these several ferro-alloys. At the present time there are a number of different types and compositions of all the ferro-alloys sold under one and the same classification. The efforts of the committee have been directed toward combining the several types into one general specification and where this was not possible the specifications have been divided into more than one class.

The chemical analysis of ferro-alloys is rather difficult and complicated. Due to this condition many different methods of analysis for the same elements have been in existence, which condition is largely due to the wide variations in chemical analysis obtained by different laboratories in reporting results of analyses on check samples. The proposed Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum being recommended for publication as tentative were prepared from the most accurate methods used today in determining the percentages of the various elements. It is intended that the procedures for analyzing ferro-tungsten and ferro-molybdenum will be incorporated, when adopted as standard, in the Standard Methods of Chemical Analysis of Ferro-Alloys (A 104 – 27).

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[1] See pp. 636 to 649.—Ed.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 547.

The election of officers for the ensuing term of two years resulted in the election of J. P. Gill, chairman, F. M. Becket, vice-chairman and Charles McKnight, secretary.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
PROPOSED TENTATIVE STANDARDS			
Tentative Specifications for Ferro-Tungsten	18	1	10
Tentative Specifications for Low-Carbon Ferro-Molybdenum	18	1	10
Tentative Specifications for Molybdenum Salts and Compounds	19	0	10
Tentative Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum	19	0	10

This report has been submitted to letter ballot of the committee, which consists of 29 members; 18 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

N. B. HOFFMAN,
Chairman.

CHARLES MCKNIGHT,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Ferro-Tungsten, for Low-Carbon Ferro-Molybdenum, for Molybdenum Salts and Compounds and Tentative Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum were accepted for publication as tentative and appear on pages 636 to 649.

REPORT OF COMMITTEE A-10

ON

IRON-CHROMIUM, IRON-CHROMIUM-NICKEL AND RELATED ALLOYS

Committee A-10 has not held a meeting since its meeting during the 1931 annual meeting of the Society. Changes in representation of one or two committee members occurred and several new members were added during the year. The present membership of the committee is 52: of whom 22 are classified as producers, 22 as consumers and 9 as general interest members.

Mr. T. H. Nelson was appointed chairman of Subcommittee I on Classification of Data, relieving Mr. Jerome Strauss, the former chairman. Mr. N. L. Mochel retired from activities of Subcommittee VI on Metallography, the chairmanship of which was taken over by Mr. C. E. MacQuigg. Mr. Mochel will act as chairman of the newly formed Subcommittee VIII on Specifications.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Classification of Data (T. H. Nelson, chairman).—Some discussion of the Tables of Chemical Compositions, Physical and Mechanical Properties and Corrosion-Resistant Properties of Corrosion-Resistant and Heat-Resistant Alloys[1] was had during the year. In the next revision of these data, it is planned to use concise text rather than tables. Descriptive matter could be revised yearly and a standard order of arrangement as to form and text adopted. Discontinuance of trade names and classification according to alloy content has been suggested.

Subcommittee III on Methods of Chemical Analysis (F. B. Foley, chairman).—During the past years, the work of the committee has consisted in gathering information leading to the adoption of a set of approved methods for the analysis of the plain chromium-iron and chromium-nickel-iron alloys. A standard sample of the 18 per cent chromium, 8 per cent nickel type of corrosion-resistant alloy containing 0.06 per cent carbon, has recently been issued by the U. S. Bureau of Standards. At the present writing this sample carries a provisional certificate of analysis. In the development of this standard, cooperating laboratories were requested to submit, with their determinations, the details of the methods used. These data are to be used for the development of recommended methods for analyzing the types of steel represented by the sample. Methods of determining special elements, such as tungsten, molybdenum and vanadium, occasionally added, will be taken up after studying the simpler alloys.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, Plates V to XV (1930).

Subcommittee IV on Methods of Corrosion Testing (W. R. Huey, chairman).—Ten of the fifteen laboratories participating in the laboratory corrosion studies of four stainless alloys have completed the collaborative testing program. Data will be tabulated for the June meeting, at which time it is expected that a complete report will be ready. The first phase of the work is considered complete and new plans for the subcommittee will be made at a meeting to be held during this annual meeting.

Subcommittee V on Mechanical Testing (I. B. McCorkle, chairman).—The membership of this committee has been completed. Present business conditions have made it impossible to begin work on the study of methods for the determination of elastic and impact properties.

Subcommittee VI on Metallography (C. E. MacQuigg, chairman).—Methods of specimen preparation and etching of alloys within the scope of Committee A-10 is the basis of the activities of this subcommittee. An outline of the principal factors that need be specified in a metallographic study of the alloys has been prepared and is to be sent to subcommittee members for discussion.

Subcommittee VII on Welding (F. B. Olcott, chairman).—The organization of Subcommittee VII is completed and some progress is reported in the collection of information on welding technique as related to the properties of welds.

Subcommittee VIII on Specifications (N. L. Mochel, chairman).—This committee has been organized and has before it the problem of the preparation of specifications; at first, on chromium steels, and subsequently, on the more common chromium-nickel steels.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 52 members; 42 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

JEROME STRAUSS,
Chairman.

H. D. NEWELL,
Secretary.

REPORT OF RESEARCH COMMITTEE
ON
FATIGUE OF METALS

During the past year this committee has held one meeting on March 8, 1932, during the Spring Group Meetings of A.S.T.M. Committees at Cleveland, Ohio.

Owing to necessity of economy in the publications of the Society, the Abstracts of Articles on Fatigue of Metals are not to be published this year. Arrangements have been made for closer cooperation between this committee and the editorial staff of *Metals and Alloys* so that all such abstracts may be available in that publication. This arrangement will probably make the abstracts appear more promptly, but they will not be gathered into a special volume.

As supplementary to the summary of present-day knowledge of fatigue of metals presented by this committee in 1930, there are presented as an appendix to this report, short articles on our present-day knowledge of corrosion-fatigue, and on the significance and limitations of fatigue test results. In connection with these summaries it seems in order to emphasize, as was done in the 1930 report, that the committee realizes that such summaries are essentially of a temporary character, and that developments may materially change their value in the very near future.

Among the subjects discussed by the committee by correspondence and in their meeting there have been the following:

1. The effect of occasional stresses above endurance limits of various metals.
2. Size effect in specimens or parts subjected to fatigue.

(The test data on this subject leave uncertain the question whether there is a size effect, or whether the ordinary values of computed stress are significant irrespective of size.)

3. Fatigue strength of light alloys.
4. Notch effects in specimens or parts.
5. Accelerated tests for fatigue strength.

(No reliable accelerated test has been developed as yet. Tests of specimens subjected to a few hundred thousand cycles of stress of varying intensities show a variation in static tensile strength after such cyclic stressing which seems worthy of further study as an accelerated test.)

Respectfully submitted on behalf of the committee,

H. F. Moore,
Chairman.

APPENDIX

SUMMARY OF PRESENT-DAY KNOWLEDGE OF FATIGUE PHENOMENA IN METALS

ARTICLES SUPPLEMENTARY TO THOSE IN THE 1930 REPORT OF THE RESEARCH COMMITTEE ON FATIGUE OF METALS

CORROSION-FATIGUE OF METALS[1]

By T. S. FULLER,[2] P. F. MUMMA[3] AND H. F. MOORE[4]

In 1913, Parker Haigh**(8)**[5] at the Royal Naval Academy at Greenwich noted a remarkable series of failures in railway passenger carriage axles at a section quite removed from those in which fatigue failures usually occur. At this section the axle was exposed to blown spray from the lavatories, and when the lavatory vents were arranged to throw the spray clear of the axles, the breakages stopped. Later during the World War, he further observed similar failures in wire ropes which were exposed to vibration while under sea water. In 1926, McAdam**(11)** reported an extensive series of tests of rotating-beam fatigue specimens exposed to a stream of water; both fresh water and salt water were tried, we found a very marked reduction of endurance limit under the influence of the stream of water. There seemed to be no very marked general corrosion of the steel, but examination under the microscope showed corrosion pitting over small areas. The following quotation from McAdam**(19)** gives his conclusions to the nature of this phenomenon:

"The conclusion was reached that corrosion-fatigue is due to the accelerating influence of stress on corrosion. Pits formed under simultaneous stress and corrosion are sharper and deeper than pits formed in the same time under stressless corrosion.

"The corrosion-fatigue process begins with corrosion pitting under the influence of the initial stress. As pitting proceeds, the actual stress rises, because of increasing stress concentration at the bottom of corrosion pits. Eventually the actual stress exceeds the endurance limit and the metal is subjected to ordinary fatigue. In the first part of this second period of corrosion-fatigue, however, the progress of pitting is due entirely to corrosion under the influence of the increasing actual stress. Late in the second period, fatigue cracks start at the bottom of corrosion pits and proceed until the metal fails.

"Even at high cycle frequency,[6] therefore, fatigue does not enter into the process until late in the second period of corrosion-fatigue. At low cycle frequency,[6] pitting may proceed entirely by corrosion, until the weakened section fails by tensile fracture."

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[1] The committee greatly regrets that Mr. D. J. McAdam, Jr., was not able to take a formal part in the preparation of this summary because of the demands of his other work.

[2] Metallurgist, Research Laboratory, General Electric Co., Schenectady, N. Y.

[3] Research Engineer, Research Laboratory, National Tube Co., Pittsburgh, Pa.

[4] Professor of Engineering Materials, University of Illinois, Urbana, Ill.

[5] The boldface numbers in parentheses refer to the reports and papers given in the list of references appended to this summary, see p. 145.

[6] NOTE BY H. F. MOORE.—McAdam's experiments covered a range of cycle frequencies from one cycle per day to 10,000 cycles per minute.

The actual visible corrosion of a specimen which fails by corrosion-fatigue is very slight; the damage is due to *sharp pitting* rather than to general corrosion and consequent reduction of section. McAdam has suggested(19) that the term "fatigue-corrosion" better describes the basic process than does "corrosion-fatigue," and he further suggests that the term "stress-corrosion" is a suitable general term to designate corrosion under the influence of stress, either cyclic or steady.

McAdam has carried out a very extensive investigation of this problem of corrosion-fatigue at the laboratories of the U. S. Naval Engineering Experiment Station at Annapolis.(11-25) This investigation "has been conducted by means of two-stage experiments. In the first corrosion stage, each specimen was corroded with or without stress. In the second stage, the previously corroded specimen was subjected to fatigue test. The lowering of the fatigue limit was used as a measure of the "damage" due to the previous corrosion. Results of these two-stage experiments, obtained with a great variety of alloys, have been presented in eight papers (13, 14, 15, 16, 21, 22, 23, 25). Diagrams of various types have been used to illustrate the influence of stress, time and number of cycles (or the influence of stress range and cycle frequency) on corrosion.

Under any given conditions of test there seems to be a fairly definite "corrosion-fatigue limit" for a metal, and this limit is of value in making a rough comparison of the behavior of metals under simultaneous repeated stress and corrosion, but this value *cannot be used directly as a basis for design;* in fact, no single numerical index has so far been found which can be used to evaluate the resistance of a metal to fatigue corrosion or to steady-stress corrosion conditions in service. One reason for this is found in the fact that while speed of reversal of stress makes very little difference in the simple (non-corrosive) endurance limit of a metal, the time of exposure to a corroding agent plays an important part in corrosion-fatigue. McAdam has used the reduction of endurance limit in any given series of tests as a measure of the damage done the metal. He calls the percentage of reduction from the endurance limit obtained without corrosion the "total damage," and the reduction of endurance limit below the value obtained from specimens subjected first to corrosion without stress as the "net damage." Stressless corrosion reduces the endurance limit somewhat, but not nearly so much as simultaneous stress and corrosion. Ordinary steels and aluminum alloys have received serious "net damage" by cycles of stress-corrosion with the stress less than half the "corrosion-fatigue" limit. Neither heat-treatment nor cold-working greatly affect the corrosion-fatigue limit of a metal.

The reduction of fatigue strength of metals by corrosion-fatigue is very marked. So far no definite lower limit of stress has been found for metals subjected for indefinite periods to corrosive agents and to repeated stress, and even under moderately long tests the endurance limit may be reduced to a value as low as one-third of its value under fatigue tests without corrosion. The corrosion-resistant materials seem to show up somewhat better under corrosion-fatigue tests than do ordinary steels, but even they are markedly affected. As might be expected, corrosion-fatigue is more marked in salt water or strongly corrosive solutions than under fresh water, but even with distilled water marked damage occurs.

T. S. Fuller (5,6) has reported experiments on specimens of steel subjected to cycles of reversed flexure in an atmosphere of steam. His results emphasize the damaging effect of simultaneous repeated stress and corrosion. The metals studied included a nickel steel, a chromium-iron alloy, nitrided steel, and steels of the austenitic group. The nickel steel and the chromium-iron alloy did not have their endurance limit seriously reduced by steam at 220 lb. per sq. in. pressure and 700° F. in the absence of appreciable quantities of liquid water and of oxygen, but under a steam jet in the atmosphere their corrosion-fatigue limit was only about half that in air. Chromium plate offered considerable protection to nickel steel against corrosion-fatigue in the steam-jet test. The endurance properties of the 18 per cent chromium, 8 per cent nickel steels were seriously affected by long exposure at 1200° F. and above.

Speller, McCorkle and Mumma (31,32) at the laboratories of the National Tube Co., Pittsburgh, have made an extensive study of the effect of corrosion accelerators and inhibitors on corrosion-fatigue. In their earlier tests they report "with water similar to Pittsburgh tap water:

"1. Corrosion under stress could be stopped with inhibitors (for example, sodium dichromate), and that under these conditions the damage due to corrosion, combined with fatigue, was absent. In other words, the corrosion-fatigue limit corresponded to or slightly exceeded the air-fatigue limit.

"2. When 'local' corrosion was present, the efficiency of the inhibitor in overcoming corrosion-fatigue was greatly reduced."

Speller, McCorkle and Mumma report that effective protection against corrosion-fatigue may be given by a protective coating on the specimen,[1] so long as that coating is not broken at any point, but that if it is broken, then corrosion-fatigue proceeds with increased rapidity at the point of fracture of the coating. Such an effect was found at the edge of a rubber washer or band of clear "Duco" placed on the specimen so as to protect *part* only of its critical section.

In discussing their results, U. R. Evans (3) makes the following statement:

"There seems no doubt that the invisible oxide film normally present on ordinary iron or steel keeps cracking or breaking down, and we only get immunity from attack when there is present at all points an oxidizing agent in sufficient quantity to repair the film as quickly as repair is needed. If the supply at some place is insufficient for proper repair, then anodic attack will commence at that place, and the presence of the oxidizing agent at the places where the film is in good repair actually stimulates corrosion at the points of breakdown, since it acts as a cathodic depolarizer. Thus the same body may either act as inhibitor or stimulator of corrosion, according to its concentration and distribution. Dissolved oxygen can act in both ways. It stimulates corrosion at the places where its concentration is low, and paradoxically prevents it where the concentration is high. In the case of pure iron in pure water, we get corrosion if the oxygen concentration is not uniform; but the same iron in the same water is passive and unattacked if the oxygen concentration is maintained uniform at all points, by means of a simple apparatus described elsewhere. Stainless iron or steel has a film more easily repaired by oxygen than that of pure iron. With ordinary commercial iron or steel it is impractical to attempt to avoid corrosion in this way; but by using another oxidizing agent, potassium chromate, inhibition often becomes a practical proposition, although even here the amount of chromate required must be increased if chlorides are present since these ions penetrate weak places where other ions cannot pass.

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[1] Tests at the University of Illinois showed good protection by means of a coating of rubber cement or elastic varnish. Parker Haigh reports that even a coating of grease is of considerable value.

"Alternating stresses keep cracking the film continually and thus accelerate corrosion, which in turn produces stress concentration, and thus the two factors (alternating stress and corrosion) cause more damage when they act together than when they act separately. The presence of a good film repairer, for example, potassium chromate, or the use of a material, for example, stainless steel, which builds an oxide film capable of being kept in repair by dissolved oxygen alone, offers promise of solving some of the problems."

Of recent years there has been much discussion of the "caustic embrittlement" of boiler steel under the action of certain boiler waters. To see whether corrosion-fatigue would take place under the action of water which had been treated so as to prevent caustic embrittlement, tests were made at the University of Illinois (**26**). Fatigue specimens showed marked lowering of endurance limit under the action of a stream of this treated water.

Parker Haigh(**9**) has made tests showing corrosion-fatigue of lead under air, an effect which does not seem to be serious in the case of steel. Possibly the low endurance limit obtained in very long-time tests of certain aluminum alloys may be partially explained by very slow air - corrosion-fatigue. However, no authoritative test data on this point are available.

To sum up very briefly, simultaneous cycles of repeated stress and corrosion by so mild an agent as fresh water may reduce the fatigue strength of a metal to a value below one-half its value for fatigue tests in air. Metals which are corrosion resistant under stressless conditions seem to be somewhat superior in their resistance to corrosion-fatigue, but are still markedly affected by simultaneous repeated stress and corrosion. While there is very little "time effect" in non-corrosive repeated stress the time of exposure to the corroding agent plays an important part in corrosion-fatigue. The mechanism of corrosion-fatigue seems to consist in the mechanical breaking down by repeated stress of the protective film of oxide which is found on nearly all metals, and consequent progressive spread of corrosion pits followed by the formation of a spreading fatigue crack. Certain inhibitors, notably sodium chromate, have been found effective in preventing corrosion-fatigue, probably by the rapid building up of a protective film counteracting tendency to break down the film locally by the action of cycles of repeated stress.

THE SIGNIFICANCE AND LIMITATIONS OF FATIGUE TEST RESULTS

BY R. E. PETERSON[1] AND H. F. MOORE[2]

The term "fatigue of metals" seems to have become rather firmly fixed in our technical language. The term arose from the supposition that under repeated stress some metals suffer a change of nature, commonly called crystallization, and become "tired" something as human muscles do after over-exertion. This idea of the nature of failure of metals under repeated stress has been completely discarded, but the term persists, although the term "progressive fracture" would be better. Moreover, the term "fatigue of metals" is sometimes applied loosely to any failure which occurs after a machine or structural part has been in service for a long time.

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[1] Manager, Mechanics Division, Research Laboratories, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

[2] Professor of Engineering Materials, University of Illinois, Urbana, Ill.

The term fatigue of metals should be used only in case of failure by a spreading crack. This spreading crack usually, if not always, starts by a plastic slipping within a crystalline grain of metal, following at first some definite atomic planes(7), and developing into a spreading crack.

To speak indiscriminately of any structure subjected to many cycles of stress as "fatigued" causes confusion. The phenomenon of fatigue has not taken place unless spreading fracture has started, even though the start be sub-microscopic.

Failures by spreading "fatigue" cracks constitute a majority of failures in machine industries. It has been stated by Aitchison of England(1) that 95 per cent of broken automobile parts have failed through fatigue. According to Roos(2), the director of the Swedish Materials Testing Laboratory of Stockholm, at least 80 per cent of all failures of machine parts which have come to his attention have been fatigue failures. The remaining 20 per cent were not static failures, but involved impact as a cause. Hardly a single failure in machine practice could be attributed to static loading alone. Sir Thomas Stanton(33) has stated "there can be no doubt that the maximum range of stress of an unlimited number of repetitions is the most valuable strength characteristic of a material which the designer of structures or machines can possess. The test does not attempt to discriminate between brittle and tough materials, which is the function of impact testing."

There is no doubt concerning the importance of fatigue in machinery. If one speaks of bridges, tanks, vats or such structures, then perhaps fatigue may not be important. Fatigue failures have been observed in motor shafts, bolts, springs, gear teeth, turbine blading, cables, armature leads, cooler tubing and welded structures, in airplane and automobile parts, in steam and gas engine parts, in railway rails, in wire rope, and in car axles.

In most *structures* fatigue failure is not of very great importance. The most common type of failure is by buckling under compressive stress above the yield strength of the metal. This plastic failure, like fatigue failure, *starts* by plastic slipping within a grain of metal, but as the failure develops, deformation, buckling and collapse may take place without the development of fracture. Fracture is characteristic of *fatigue* failure; deformation, buckling and collapse is characteristic of failure of *elastic strength*, and the two types are quite distinct. In most structures, the number of repetitions of stress is small, and it is rare that fatigue cracks develop under less than several thousand repetitions of stress. Moreover, in many structures there is a long lapse of time between successive applications of load and a good chance of detecting cracks in their early visible stages and of repairing the damage before complete fracture has taken place.

Metal pressure vessels seem to form a group intermediate between structures and machines in respect to danger of fatigue failure. They are subjected to some thousand repetitions of stress in their normal life, but the chance for inspection of cracks is fairly good. At the present time they may be regarded as an intermediate type between structures and machines. Obviously some pressure vessels, such as large storage tanks, would not be subjected to many cycles of stress and fatigue failure need not be considered in their design. Other vessels, such as steam boilers, may be required to withstand a good many thousand cycles of stress in their "life time,"—this would be especially true of locomotive and marine boilers. At present each pressure vessel problem should be studied by itself to determine whether it is necessary to consider the danger of fatigue failure.

The determination of the endurance limit[1] (29) is the obvious test for resistance of materials to fatigue failure. However, this is a very time-consuming test, and a number of proposed short-time tests to determine endurance limit have been proposed, but have not proved to be reliable. Moreover, except for cases of stress involving partial or complete reversals, the fatigue strength of most metals is higher than their yield strength, and when that is the case, fatigue strength is no longer the determining factor. For most metals some idea of fatigue strength can be obtained from static tensile strength(28), although the ratio of the two values varies widely for different types of metals. Probably in any special case a fair idea of the endurance limit may be obtained by examining the published results of fatigue tests and of static tests for a number of metals of somewhat similar composition and treatment and determining an approximate "endurance ratio,"—that is, the ratio of *endurance limit* to *tensile strength*. Then, applying this ratio to the tensile strength of the material in question, a fair estimate of the endurance limit can be made. Of course, a direct determination of endurance limit would be preferable if time permits. It should be noted that the endurance limit under cycles of reversed shearing stress is usually about half that under cycles of alternating tensile and compressive strength, and that the endurance limit for cycles of stress varying from zero to a maximum is at least 50 per cent (and probably more) higher than that for cycles of completely reversed stress.

The following quotation from Soderberg(30) is of interest in connection with the significance of endurance limit.

"In the case of alternating or pulsating stresses in brittle materials, the endurance limit for tension or compression is taken as a basis for the working stress.

"Brittle materials have very unfavorable properties under variable stress, however, and their behavior under variable stress cannot be predicted with any degree of certainty. For this reason, brittle materials should be avoided where variable stress is involved. In those exceptional cases where this is not possible, the working stresses should be determined on the basis of the maximum-strength theory,[2] and very large factors of safety must be used."

For metal parts subjected to high temperature we have very few data concerning fatigue failure. Apparently at some temperature the tendency for a metal to fail by "creep," that is by slow continuing flow, becomes dominant and the problem of fatigue failure fades out of the picture. For ordinary structural steel, some tests have indicated that this temperature is in the vicinity of 1000° F.(27) and further tests on this point are being carried on under the auspices of the Joint A.S.M.E.-A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals.

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[1] *Endurance Limit or Fatigue Limit.*—The stress below which a material will resist an indefinitely large number of cycles of stress without failure. Usually the term implies cycles of completely reversed stress.

[2] NOTE BY H. F. MOORE.—Some designers prefer to use the maximum strain theory, or the maximum strain energy theory for brittle metals.

Ductility in a metal is sometimes supposed to be an index of serviceability under repeated stress. Ductility has no direct connection with the endurance limit of a metal. Hard brittle metals develop higher endurance limits than soft ductile metals. The advantage of ductility in a part to be subjected to cycles of stress lies in the ability it confers on the metal to make scores of slight plastic adjustments under load without starting a crack. Tens of thousands of cycles of stress may start a spreading crack in a ductile metal, but a few score of cycles, even of high stress, will not do so.

A slight plastic adjustment under the first few cycles of load will greatly mitigate any localized stresses which may occur during succeeding cycles in a machine part, and it is this ability to mitigate high localized stress which makes it advisable to consider ductility as well as strength in selecting metal for parts to be subjected to repeated stress.

The ordinary methods of determining ductility do not, unfortunately, give assurance of ability of a metal to undergo a few score of plastic adjustments without starting a crack. The measurement of elongation, reduction of area or angle of bend without cracking measures the ability of a metal to withstand *one* extreme load without fracture. No tests have been standardized as yet for determining the ability of a metal to withstand a few hundred loads each involving slight plastic action, although some modification of the notched-bar impact test seems rather vaguely promising, and the Foeppl-von Heydekampf test(**4,10**) for rate of dying out of free vibration in a metal specimen gives rather distinct promise of usefulness.

To sum up briefly, fatigue failure is perhaps the commonest type of failure in machine parts. It is comparatively rare in structures. Pressure vessels seem to be in an intermediate class.

The endurance limit seems to be the best criterion for judging resistance of a metal to fatigue failure. At high temperatures, fatigue failure may be important below a certain temperature range, but above that range creep may become the dominant factor.

It is obvious that in designing any machine or structural part, careful consideration should be given to the type or types of failure likely to occur, and that a criterion of strength should be selected only after such consideration.

The term "fatigue of metals" should be used only in reference to actual failures of structural or machine parts by a spreading crack.

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REPORT OF JOINT RESEARCH COMMITTEE
ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

The Joint Research Committee has made measurable progress during the past twelve months despite the handicaps imposed by economic conditions. Curtailments in activities at some of the cooperating laboratories retarded progress in certain projects but, in general, the plans outlined a year ago were carried forward.

Organization and Membership:

It may be recalled that the committee was reorganized during 1930 with the idea of providing more effective means for carrying on its researches and of securing wider representation from the many groups interested in the effects of temperature upon metals. It is perhaps not generally known that this reorganization resulted in the formation of one of the largest groups active in cooperative metallurgical research. No doubt this, and certain unusual features of the committee's organization are responsible for the several requests received during the year that organization and membership be recorded in detail in the 1932 report to the sponsor societies. This information is shown in Fig. 1.

As will be noted, the membership of the Joint Committee itself is relatively small and its activities are carried on mainly through subcommittees working under three standing committees. One of the advantages of this form of organization is its flexibility which enables expansion or contraction to meet particular conditions.

Membership in the Joint Committee involves responsibilities which cannot be accepted by many who are actively interested in the effects of temperature on metals while others have restricted interests and wish to take part only in certain phases of the work. To secure the active cooperation and maintain contact with these several groups, an advisory and cooperating membership was established. This scheme, which is somewhat novel in the organization of engineering research committees, has been in operation for about two years and appears to the members and officers of the Joint Committee to provide effective cooperation and satisfactory contacts.

It is with deep regret that the officers of the Joint Committee record the death of their friend and associate Mr. L. W. Spring who, until his failing health caused his resignation as chairman of the Committee on Projects, directed the research program of the Joint Committee. This important post has since been accepted by Mr.

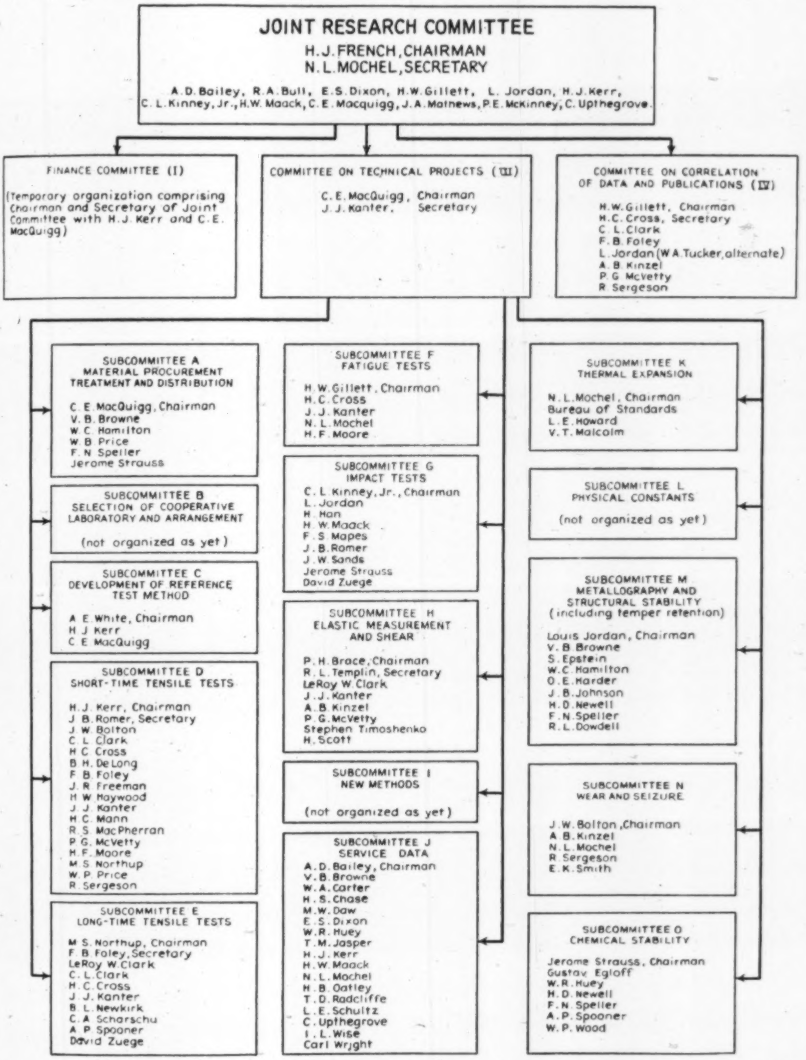
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Fig. 1.—Joint Research Committee Membership and Organization as of June, 1932.

C. E. MacQuigg. With a few other exceptions the membership of the Joint Committee remained stable throughout the year.

Meetings:

Probably the most important project under committee sponsorship which matured during the past twelve months was the second Symposium on Effect of Temperature on the Properties of Metals, held at the Annual Meeting of the American Society for Testing Materials in Chicago, Ill., June, 1931.

The objects and details of this symposium have already been recorded in the *Proceedings*[1] of the sponsor societies and need not be referred to again in detail, but during the past year the 27 papers and voluminous discussions were carefully indexed and combined with a bibliography in a bound volume comprising some eight hundred printed pages.[2] This now gives an up-to-date summary of knowledge of the properties of metals for high- and low-temperature service and the engineering requirements of many important industries in this field.

The Joint Committee held three additional meetings, one in Chicago, Ill. in June, 1931, another in New York City in December, 1931, and one in Cleveland, Ohio, in March, 1932.

Finance and Sponsored Researches:

About eighteen months ago the Joint Committee and the sponsor societies approved plans for the establishment of a fund of $20,000 designed to enable the initiation of sponsored researches. These proposed activities were not intended to replace the cooperative researches already under way relating to problems requiring joint action such, for example, as the development of test codes for high-temperature tension tests and creep tests, but rather to take care of those fundamental problems involving prolonged effort, and special equipment, which could not well be carried out in an accustomed manner.

Despite the adverse economic conditions prevalent during the past year contributions already made enable the Joint Committee to carry forward its plans during 1932 and part of 1933.

The contributors and the funds which have been made available to date are as follows:

National Electric Light Association	$3000
Engineering Foundation	3000
National Research Council (for specific projects)	2000
American Petroleum Institute	1000
Alloy Castings Manufacturers Association	280
Total	$9280

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 17 to 19 (1931).

[2] Symposium on Effect of Temperature on the Properties of Metals published jointly in 1931 by the American Society for Testing Materials and The American Society of Mechanical Engineers.

It is hoped that the plans now being developed will provide additional funds by which to continue the sponsored researches already under way and also to initiate work in new fields for which requests have already been received.

With the funds available, sponsored researches were initiated at two laboratories early in 1932. The work at the University of Illinois, under Mr. H. F. Moore, will relate largely to the endurance properties of austenitic nickel-chromium steels at different temperatures and will be coordinated with creep tests at the Battelle Memorial Institute, under Mr. H. W. Gillett, as well as with studies at various industrial laboratories relating to the structural stability of these steels and the changes in various properties with time at high temperatures.

Consideration will be given to wrought and cast metals from the same melts and in the case of the 18 per cent chromium, 8 per cent nickel steels, to the effects of carbon content and preliminary heat treatments on the chemical, mechanical and structural stability of this widely used alloy steel.

At ordinary atmospheric temperatures the limiting stresses for design purposes are the repeatedly applied stresses (resistance to fatigue). While only a limited amount of data are available, there is evidence to indicate that the limiting stresses for steels at 1000° F. are not the repeatedly applied stresses but the ability of the metal to sustain fixed loads (resistance to creep). Further information is needed to confirm these views and to define better in the case of the austenitic nickel-chromium steels the temperature ranges within which the repeatedly applied stresses and the ability to sustain fixed loads become the limiting stresses for design purposes.

The procurement of information of this sort is one of the important objects of these investigations and has considerable practical importance because of the widespread applications of austenitic nickel-chromium steels. It is also of scientific interest because most prior comparisons have been made on the pearlitic steels and the proposed tests should help to establish whether or not comparable relations exist in the austenitic steels.

In arranging for the details of this program it was necessary to procure relatively large quantities of specially prepared samples and this has been made practicable, at a nominal cost, through the cooperation of the Babcock & Wilcox Co.

Cooperative Researches, Reports and Abstracts:

Researches at cooperating laboratories relating to cast and wrought carbon steels have been continued during the year and many of the subcommittees shown in Fig. 1 have been laying plans for the development of data in their respective fields.

Among the projects which have been carried far enough to justify detailed reports are those relating to (1) correlation of tension, creep and fatigue properties of low-carbon (0.17 per cent) boiler steel at elevated temperatures and (2) a cooperative study of the notched-bar impact properties, magnetic properties and structure of the 18 per cent chromium, 8 per cent nickel "stainless steels" under different conditions of treatment. These several technical reports from subcommittees are appended to this report.

Bibliographic Work:

Plans were perfected during the year by which important articles relating to the effect of temperature on the properties of metals are abstracted regularly and published monthly under a separate heading in the abstract section of *Metals and Alloys*. This provides continuous contact with progress in this and foreign countries as recorded in technical literature and replaces the previous plan of issuing bi-annual additions to the bibliography on effect of temperature on the properties of metals first published by The American Society of Mechanical Engineers in 1928.

Respectfully submitted on behalf of the Joint Committee,

H. J. FRENCH,
Chairman.

N. L. MOCHEL,
Secretary.

CORRELATION OF TENSION, CREEP AND FATIGUE TESTS OF 0.17 PER CENT CARBON STEEL AT ELEVATED TEMPERATURES

Introduction.—Beginning in 1927, four reports[1] have been published in the *Proceedings* of the American Society for Testing Materials relative to the properties of a 0.17 per cent carbon steel as revealed by short-time tension, long-time tension, and fatigue tests at elevated temperatures. Thirteen laboratories have cooperated in making the short-time tension tests but up to the present time data are available from only one laboratory each for the creep tests and fatigue tests. It is unfortunate that we are unable to correlate results from several laboratories for each kind of test before comparing the different tests, but it seems desirable to bring together the main points from the four papers without further delay.

Material.—The material, which has been designated "K1," has the following chemical composition:[2]

Carbon, per cent	0.17
Manganese, per cent	0.42
Phosphorus, per cent	0.012
Sulfur, per cent	0.035

The material was rolled to 1-in. rounds, heated to from 1650 to 1700° F. (900 to 925° C.) for 1 hour and air cooled.

Kanter and Spring[3] have made a comparison of the short-time and creep test data and Fig. 1 reproduces their Fig. 17(a).[4] On this has been plotted the results of Moore and Alleman's tests.[1] The curve is shown dotted because only four points are available and the values for 800° F. and 1200° F. are probably high. This probability is indicated by the arrows within this temperature range. In the absence of more points, the curve up to 600° F. has been given the same form as the tensile strength curve on the assumption that the endurance ratio is approximately constant in this temperature range.

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[1] Preliminary Report on Comparative High-Temperature Tension Tests on a Carbon Steel and on a Chromium-Molybdenum Steel at Different Laboratories, *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 143 (1927).

Second Report on Comparative High-Temperature Tension Tests of Metals at Different Laboratories, *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 96 (1930).

J. J. Kanter and L. W. Spring, "Some Long-Time Tension Tests of Steels at Elevated Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 110 (1930).

H. F. Moore and N. J. Alleman, "Progress Report on Fatigue Tests of Low-Carbon Steel at Elevated Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 114 (1931).

[2] Analysis made by manufacturer.

[3] *Loc. cit.*

[4] See *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 127 (1930).

It is impossible to say how low the endurance curve may fall if the tests are further prolonged. Moore and Alleman state that no clearly defined endurance limit was obtained at 800 and 1200° F., although some tests were run to 43,000,000 cycles of stress. This indicates that high-temperature endurance tests of ferrous materials may be similar to normal temperature tests of some non-ferrous materials in the requirement that the test be prolonged to a very high number of cycles. Unless this is done, the values found may be considerably in error.

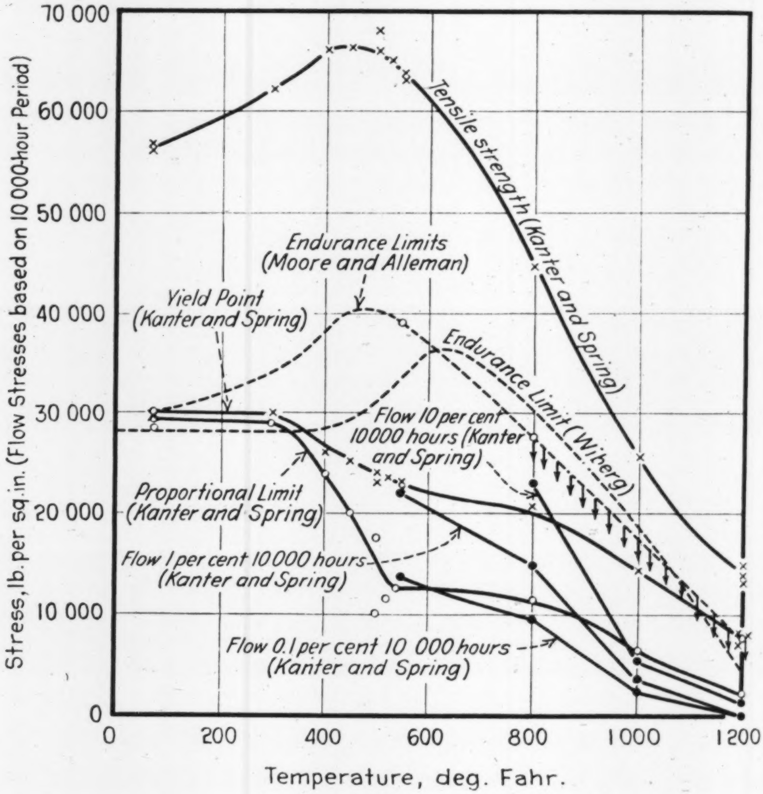

FIG. 1.—Correlation of Tension, Creep and Fatigue Tests of 0.17 per cent Carbon Steel at Elevated Temperatures.

A comparison with the endurance limits published by Wiberg[1] is interesting. His tests were made on a 0.15 per cent carbon steel normalized at 920° C. (1688° F.) and his endurance curve has been added to Fig. 1.

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[1] O. A. Wiberg, "High Pressures and High Temperatures for Steam Prime Movers," *Transactions,* World Power Conference at Tokyo, Vol. III, p. 1131 (1929).

The author gives no discussion of the test methods used but he mentions the short time available for his creep tests and it seems fair to assume that the endurance tests represent fewer cycles than appear to be necessary from Moore and Alleman's tests.

Wiberg's maximum tensile strength was found at approximately the same temperature as that for material K1. It would be expected that his maximum endurance limit would occur at approximately the same temperature instead of about 200° F. higher. This indicates a possible error in temperature measurement which might require that the curve be shifted to the left. Such a shift would bring the results into closer agreement with the work of Moore and Alleman.

In a similar manner, other creep tests may be compared with the results of Kanter and Spring but the uncertainty always exists as to how much of the difference is due to materials and how much to test methods.

The curves indicate that a design based upon allowable deformation within the life of the material in service will not result in a fatigue failure. This conclusion refers to K1 steel and further tests are necessary to establish any law.

From the information available, it is recommended that further correlation of K1 data await additional creep and endurance tests on the same material at different cooperating laboratories.

Respectfully submitted,

P. G. McVetty
H. C. Cross
For Committee IV on Correlation of Data and Publications.

COOPERATIVE STUDY OF CHARPY NOTCHED-BAR IMPACT TESTS OF 18 PER CENT CHROMIUM, 8 PER CENT NICKEL, STAINLESS STEELS

REPORT OF SUBCOMMITTEE G COMPILED BY MR. H. C. T. HAN

Materials and Objects of Tests:

Subcommittee G on Impact Tests received from Committee III on Technical Projects of the Joint Research Committee on Effect of Temperature on the Properties of Metals specimens representing commercial 18 per cent chromium, 8 per cent nickel, stainless steel of two ranges of carbon content, specified to be respectively, carbon less than 0.07 per cent and carbon between 0.08 and 0.12 per cent. These two steels were designated respectively as K9c and K9d materials.

Material K9c.—Material K9c was supplied by the Crucible Steel Co. and was regular commercial material, not a specially made heat. No data are available on melting method, size of ingot or reduction schedule in rolling. Analyses are reported as follows, on different bars of the lot:

	Carbon per cent	Chromium, per cent	Nickel, per cent	Silicon, per cent	Manganese, per cent	Sulfur, per cent	Phosphorus, per cent
Maker's analysis..	0.06	18.32	8.70	0.68	0.56	0.013	0.015
Crane Company .	0.05	17.52	8.16	....	....	....	....
	0.07	17.78	8.19				
Union Carbide and Carbon Research Laboratories . . .	0.057	18.11					
	0.056	18.05	8.52	....	....	....	....
Rounded average	0.06	18.0	8.5				

The discrepancies in the analyses for chromium and nickel probably indicate some segregation in different bars of the heat. However, the material is of the 18 per cent chromium, 8 per cent nickel type with carbon not over 0.07 per cent, as specified.

In the natural, as-rolled condition, the brinell hardness varied between 179 and 217. The material was normalized from 1945° F. (hereinafter referred to as 1950° F.). The normalized specimens had a brinell hardness range of 136 to 149. Water quenching was done from 2060° F. (hereinafter referred to as 2100° F.). The treatment was performed on rolled bars 4 in. long by $\frac{5}{8}$ in. square. The quenched specimens had a brinell hardness range of 137 to 156.

In the figures and tables shown herein no differentiation has been made to show that the K9c material was water quenched from a temperature 40° F. lower than the K9d material.

Material K9d.—Material K9d was supplied by the Allegheny Steel Co., from a commercial heat and rolled from a 500-lb. ingot. Analyses are reported as follows:

	CARBON, PER CENT	CHROMIUM, PER CENT	NICKEL, PER CENT	SILICON, PER CENT	MANGANESE, PER CENT	SULFUR, PER CENT	PHOSPHORUS, PER CENT
Maker's analysis.	0.085 0.09	18.35	9.20	0.28	0.51	not determined	not determined
Crane Company.	0.081 0.085	18.11	9.12	....	....	....	....
Average........	0.085	18.23	9.16	....	....	....	....

The carbon content is thus shown to be within the specified range. The nickel is higher than in material K9c and the silicon is lower.

No brinell hardness data have been supplied. Normalizing was done from 1950° F., water quenching from 2100° F. The specimens were treated in $\frac{5}{8}$ in. square, but were cut to the length (2 in.) required for impact testing, before treatment.

Each steel was supplied in three initial conditions, namely, as rolled, water quenched from 2100° F. and air quenched from 1950° F. In addition to each of these initial conditions, the specimens have also been subjected to a subsequent 1000-hour draw at one of the following five temperatures, namely, 800, 1000, 1200, 1400 and 1600° F.

It was the object of the tests carried out by Subcommittee G to determine the notched-bar impact strength of these two steels in the three initial conditions, to determine the changes in impact strength brought about by the 1000-hour annealing treatments at the five temperatures, and also to determine the effect of a relatively brief (3-hour) annealing at 1600° F. on the impact strengths of all specimens, particularly the effect on the recovery of impact strength on those specimens rendered brittle by the 1000-hour annealing treatments.

Testing:

The specimens were distributed to four cooperating members of the subcommittee, each member receiving 108 specimens, 54 specimens of K9c material and 54 specimens of K9d material. Each group of 54 specimens represented three sets of 18 bars each from the three initial treatments, as rolled, water quenched from 2100° F.

and air quenched from 1950° F. Of the 18 specimens in each group three each had been subjected to a 1000-hour draw at 800, 1000, 1200, 1400 and 1600° F., respectively, and the remaining three specimens given no reconditioning treatment. These different sets were so distributed that half of them were tested in the "as received" condition, termed set No. 1, and half of them set No. 2 tested after they had been heated for 3 hours at 1600° F. and air cooled. As a result there were six individual impact values for each initial and final treatment for the K9c and K9d materials. The Charpy impact specimen used in the tests is shown in Fig. 1.

The individual results by each cooperator and the averages are given in Table I and graphically represented in Figs. 2 to 6.

The tests were made at room temperature which varied from 64 to 80° F. Such variation for testing of this grade of steel with high impact strength is believed to be of no significance in the results.

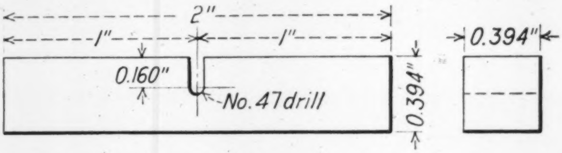

FIG. 1.—Charpy Notched-Bar Impact Test Specimen.

Due to the various types and the limitations of the testing machines used by the different cooperators, the amplitudes of pendulum swing varied from 110 to 224.1 ft-lb. In general, the impact values obtained for each treatment from the 110 ft-lb. machine were slightly higher than those from the 115 to 122 ft-lb. machine. On the other hand the results of the 224.1 ft-lb. swing checked very closely with those of the 115 and 122 ft-lb. machines. It seems that the differences in the pendulum swing were not as much a cause of variations in the results as were the individual characteristics of the different machines and set-ups employed. It is very significant too that the "off" values are all on the high side of the average values and they are also the values from tests in which the specimens were fractured but did not entirely break off. It is reasonable to assume that when such a condition exists during the test, the registered impact value represents the true impact value plus the equivalent energy due to the friction and springy action between the ends of the unbroken off specimen and the supports. Such conditions similarly occur on the Izod machine when a steel of such magnitude of impact value is being tested.

TABLE I.—RESULTS OF CHARPY NOTCHED-BAR IMPACT TEST OF 18 PER CENT CHROMIUM, 8 PER CENT NICKEL STAINLESS STEELS.

NOTE.—R = As Rolled. WQ = Water Quenched from 2100° F. AQ = Air Quenched from 1950° F.

Cooperator	Treatment	Charpy Impact, ft-lb.												Remarks
		Set No. 1: Specimens Tested After Heat Treatments Shown Below						Set No. 2: Specimens Tested After 3-hour Re-anneal at 1600° F.; Subsequent to Heat Treatments Shown Below						
		As Rolled, Water or Air Quenched	1000-Hour Draw					As Rolled, Water or Air Quenched	1000-Hour Draw					
			At 800° F.	At 1000° F.	At 1200 F°.	At 1400° F.	At 1600° F.		At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.	
MATERIAL K9C (LESS THAN 0.07 PER CENT CARBON)														
Babcock & Wilcox Co..	R...	72	74	55	45	62	52	81	78	77	84	86	90	Amplitude of pendulum swing = 110 and 125 ft-lb Testing temperature, 70° F.
								74	80	87	86	87	125[a]	
	WQ.	100	94	86	64	40	48	90	110+[a]	110+[a]	87	63	64	
								104	100	125[a]	125[a]	80	75	
	AQ.	110+[a]	98	81	58	51	49	89	102	110+[a]	106	82	80	
								125[a]	77	106	101	77	85	
Bureau of Standards...	R...	72.9	72.9	58.0	49.1	54.4	50.8	72.9	78.7	74.8	80.6	78.7	71.0	Amplitude of pendulum swing = 224.1 ft-lb. Testing temperature, 80° F.
		76.7	80.6	61.6	52.6	54.4	52.6							
	WQ.	84.6[a]	84.6[a]	82.6	63.4	45.7	54.4	112.6	94.5	88.5	80.6	74.8	65.3	
		88.5[a]	82.6[a]	78.7[a]	58.0	42.3	49.1							
	AQ.	86.5[a]	86.5[a]	74.8	56.2	50.8	54.4	86.5	90.5	86.5	72.9	69.1	78.7	
		78.7[a]	80.6[a]	72.9[a]	52.6	47.4	49.1							
Illinois Steel Co. (South Works).....	R...	66	65	53	43	51	49	73[a]	77[a]	89[a]	80	75	81	Amplitude of pendulum swing = 122 ft-lb. Testing temperature, 64° F.
		68	70	51	45	55	54							
	WQ.	84[a]	82[a]	73[a]	60	36	46	107[a]	90[a]	103[a]	93	73	67	
		84[a]	84[a]	76[a]	58	37	46							
	AQ.	76[a]	77[a]	70[a]	54	47	46	81	104[a]	90[a]	76	74	69	
		82[a]	82[a]	70[a]	57	47	48							
International Nickel Co..	R...	68.5	72	48	44	55	54.5	84	78.5	85.5	86	84.5	78	Amplitude of pendulum swing = 115 ft-lb. Testing temperature, 68° F.
								68	69.5	67.5	67.5	80.5	88.5	
	WQ.	80.5	83.5	76	62	32	49	83.5	95.5	107	95.5	78	69.5	
								91.5	85	83.5	77.5	75.5	63	
	AQ.	75	85.5	72	54.5	48	46	91	100	98.5	90	78.5	71	
								85	86.5	80	74.5	72	60	
Average of 6 Values....	R...	71	73	55	47	55	53	76	77	80	81	82	82	
	WQ.	87	85	79	61	40	49	98	96	99	87	74	67	
	AQ.	82	82	74	56	49	49	86	94	94	84	75	74	
MATERIAL K9D (0.08 TO 0.12 PER CENT CARBON)														
Babcock & Wilcox Co..	R...	73	44	39	40	47	54	69	95	77	83	80	82	Amplitude of pendulum swing = 110 and 125 ft-lb. Testing temperature, 70° F.
								84	77	78	74	81	81	
	WQ.	110+[a]	110+[a]	94	56	42	48	79	77	110+[a]	82	63	64	
								125[a]	88	125	82	63	61	
	AQ.	110+[a]	96	83	54	39	43	96	81	84	76	69	63	
								91	87	83	78	66	64	
Bureau of Standards...	R...	52.6	45.7	39.1	42.3	47.4	47.4	72.9	71.0	61.6	67.2	71.0	65.3	Amplitude of pendulum swing = 224.1 ft-lb. Testing temperature, 80° F.
		56.2	49.1	44.0	42.3	47.4	50.8							
	WQ.	84.6[a]	82.6[a]	78.7	54.4	44.0	40.7	78.7	78.7	78.7	67.2	56.2	56.2	
		80.6[a]	90.5[a]	80.6[a]	56.2	42.3	42.3							
	AQ.	74.8[a]	84.6[a]	80.6[a]	58.0	42.3	42.3	71.0	76.7	71.0	71.0	59.8	54.4	
		76.7[a]	82.6[a]	74.8[a]	52.6	40.7	42.3							
Illinois Steel Co. (South Works).....	R...	47	46	38	41	48	48	73	84	73	74	76	75	Amplitude of pendulum swing = 122 ft-lb. Testing temperature, 64° F.
		66	84[a]	37	44	50	49							
	WQ.	79[a]	85[a]	78[a]	55	41	43	83	78[a]	79[a]	73	61	59	
		83[a]	87[a]	83[a]	55	38	44							
	AQ.	79[a]	76[a]	71[a]	50	39	40	63	75	76	65	58	58	
		75[a]	79[a]	77[a]	51	37	43							
International Nickel Co...	R...	48.5	43.5	36	43.5	48	49	77.5	102	71	72.5	78.5	78.5	Amplitude of pendulum swing = 115 ft-lb. Testing temperature, 68° F.
								71.5	62.5	57.5	72	60	77	
	WQ.	84.5	88.5	81	58	35.5	40.5	100	94	91.5	71	65	57.5	
								89	90	70	69	51	55	
	AQ.	79.5	89.5	79.5	50	36.5	42.5	85	84	83	76.5	61	64	
								82.5	68	75.5	60.5	49.5	57	
Average of 6 Values....	R...	57	46	39	42	48	50	75	74	70	74	75	76	
	WQ.	83	87	83	56	41	43	86	84	80	74	60	59	
	AQ.	77	85	78	53	39	42	81	79	79	71	61	60	

[a] Indicates specimen fractured but not broken off.

On Figs. 2 to 6 it is to be noticed that the individual values for each treatment check very closely for set No. 1 with the exception of one set of values by one of the cooperators. The values of the X-specimens, which did not have the 1000-hour treatment, showed greater variation than the ones so treated. This is probably due to non-uniformity of structure or the residual stresses being greater after the initial treatments and being minimized through the long-time treatment.

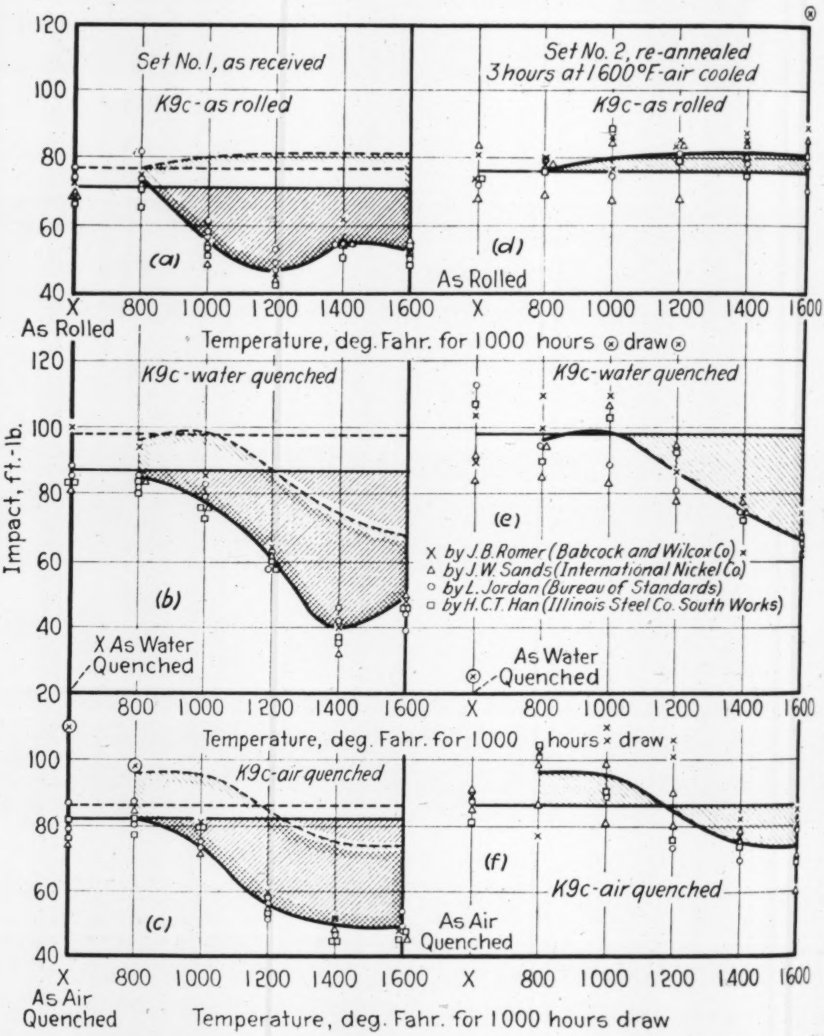

FIG. 2.—Results of Charpy Impact Tests of 18 per cent Chromium, 8 per cent Nickel Stainless Steels (Material K9c).

Specimens tested at room temperature varying from 64 to 80° F.
Amplitude of pendulum swing 110 to 224 ft-lb.

The plots for set No. 2, Figs. 2 and 3, show greater variation among the individual results for each treatment. Such variations were probably due to the differences involved in the 3-hour 1600° F. reannealing operation carried out by the individual cooperators.

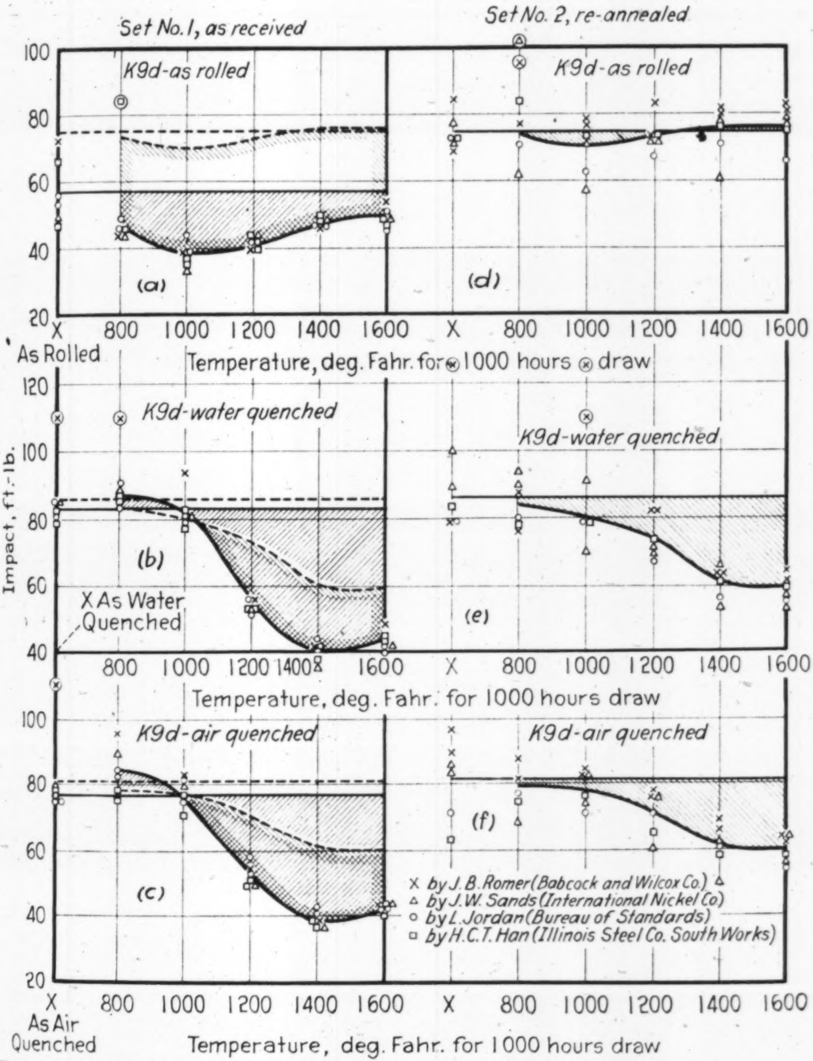

FIG. 3.—Results of Charpy Impact Tests of 18 per cent Chromium, 8 per cent Nickel Stainless Steels (Material K9d).

Specimens tested at room temperature varying from 64 to 80° F.
Amplitude of pendulum swing 110 to 224 ft-lb.

In summarizing these results, the six impact values for each treatment were averaged as shown in Table I and represented by the heavy solid curves in Figs. 2 and 3. In the averaging, values which showed too great a deviation from most of the other values were left out as shown in Figs. 2 and 3, encircled.

The solid horizontal line on each curve represents the impact value after each intitial treatment and before the 1000-hour treatment. This line is used as the datum to study the deviation of the impact strengths due to the 1000-hour treatment at the various temperatures. The cross-lined area represents the change in impact value and the temperature range in which changes of impact took place after the 1000-hour treatment. Table II summarizes the critical temperature or the temperature range which showed maximum deviations and the corresponding percentage of deviation of impact values from the datum.

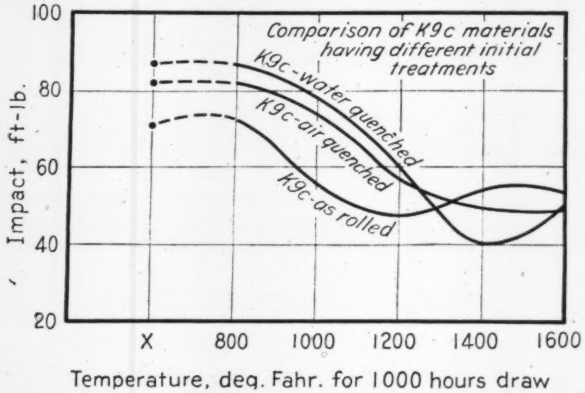

FIG. 4.—Average Curves Showing Relative Impact Strengths of Material K9c Having Different Initial Treatments.

A graphic comparison was made between the impact results of set No. 1 of the "as-received" specimens and set No. 2 of the 3-hour 1600° F. re-annealed specimens as shown in Figs. 2 and 3.

The broken curves and datum lines are those of set No. 2 (Figs. 2 and 3). The vertical dimensions of the counter cross-lined areas represent the amount of recovery of impact strength of the 1000-hour treated specimens after the 3-hour 1600° F. re-anneal.

Figures 4 and 5 are average curves from Figs. 2 (*a*) (*b*) (*c*) and 3 (*a*) (*b*) (*c*), showing the relative impact strengths of K9c and K9d materials having different initial treatments.

In Fig. 6 are curves showing the relative impact strengths between the K9c and K9d materials having the same initial treatment.

Discussion of Results:

A. Results of Set No. 1, Specimens Tested "As-Received."—Upon examining the curves in Figs. 2 to 6 and values of Table I it is noticed that the water-quenching or air-quenching initial treatments produce appreciably higher impact values than does the "as-rolled" for both lower and higher carbon steels. The 1000-hour anneal in general does not embrittle the steel at 800° F. with the exception of the 0.085 carbon steel in the "as-rolled" condition.

At 1000° F. the embrittlement begins to be noticed, particularly with the initially "as-rolled" specimens, Figs. 2 (*a*) and 3 (*a*), and also values of Table II show that for the "as-rolled" materials the critical temperature range or the temperature range in which greatest change of impact values occur is 1100 to 1300 ° F. for K9c and 900 to 1200° F. for K9d steels. On the other hand, the water-quenching and air-quenching treatments greatly embrittle the steels in the temperature range of 1300 to 1600° F.

TABLE II.—SUMMARY OF CRITICAL TEMPERATURES AND DEVIATION OF IMPACT VALUES.

NOTE.—R = As Rolled. WQ = Water Quenched from 2100° F. AQ = Air Quenched from 1950° F.

Designation of Treatments		"As-Received" Critical Temperature Range	"As-Received" Deviation of Impact Value, per cent	After 3 Hours Re-anneal at 1600° F. Critical Temperature Range	After 3 Hours Re-anneal at 1600° F. Deviation of Impact Value, per cent
Material K9c	R. .	1100 to 1300° F.	−35	1000 to 1600° F.	+18
	WQ.	1300 to 1500° F.	−54	1500 to 1600° F.	−32
	AQ.	1400 to 1600° F.	−42	800 to 1000° F.	+12
				1400 to 1600° F.	−15
Material K9d	R. .	900 to 1200° F.	−32	900 to 1100° F.	− 7
	WQ.	1300 to 1600° F.	−52	1400 to 1600° F.	−33
	AQ.	1400 to 1600° F.	−51	1400 to 1600° F.	−27

The noticeable difference in the location of the critical temperature range between the "as-rolled" and water- or air-quenched steels is probably due to the difference in grain size and residual strains present after such initial treatments. The much smaller grain size and much greater residual strain in the "as-rolled" steel aid the rate of carbide precipitation, since the initial precipitation of carbides is along the grain boundaries and slip lines. Therefore, an appreciable amount of carbide, or possibly the maximum amount of carbide that will separate out during the 1000-hour period, precipitates at 900 to 1300° F. but not for the water- or air-quenched steels, in which the rates of carbide separation increased rapidly with the increase of temperatures beyond 1300° F. It is, therefore, reasonable that the critical temperature range for quenched specimens should be 1300 to 1600° F. and not lower.

The slight increase in impact values of the "as-rolled" steel beyond 1200° F. indicates that the embrittlement has ceased to increase after the maximum carbide precipitation has been reached during such a period, while the higher temperature has partially relieved the residual strains.

It is also significant to note in Figs. 2 (*a*) (*b*) (*c*) and 3 (*a*) (*b*) (*c*) that the actual impact value at the critical temperature range is practically the same for steels with different initial treatments, even though the as-rolled material has a considerably lower impact strength before the 1000-hour treatment.

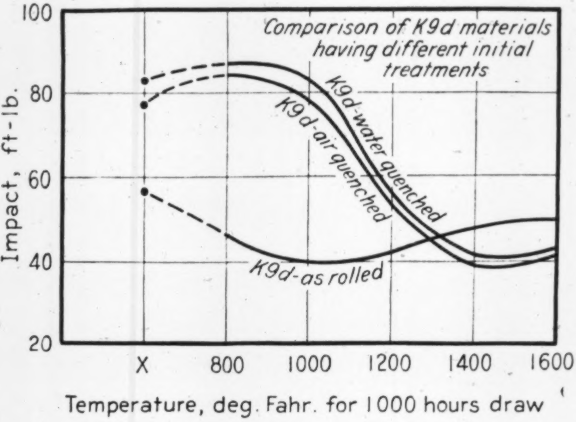

FIG. 5.—Average Curves Showing Relative Impact Strengths of Material K9d Having Different Initial Treatments.

B. Results of Set No. 2, Specimens Tested After Re-annealing at 1600° F. for 3 Hours and Air Cooled.—Three hours of re-annealing at 1600° F. followed by air cooling, definitely removes some of the embrittlement caused by the 1000-hour treatment at different temperatures. It is to be noted in Figs. 2 (*d*) and 3 (*d*) that this brief annealing has practically restored the full impact strength in the as-rolled specimens. As for the water- and air-quenched series, appreciable recovery has resulted. A better picture of the extent of this recovery of impact strength is shown in Figs. 2 (*a*) (*b*) (*c*) and 3 (*a*) (*b*) (*c*) in which the broken curves of the re-annealed specimens are compared with the solid curves for the "as-received" specimens. For the as-rolled steels there is not only full recovery but an appreciable increase over the original values. The re-annealing of the K9c steel results in complete recovery in the quenched specimens up to 1200° F., beyond which there is over 50 per cent recovery. The extent of the recovery of impact strength of the K9d steel is relatively less, but is still very noticeable.

The full or partial recovery of impact strength due to the short-time anneal at 1600° F. is likely due to the partial dissolution of carbides originally precipitated at the lower temperatures and also probably due to the faster air cooling rate which retains a large amount of the dissolved carbide in solution that otherwise would be precipitated out through the slow cooling, as it was in the case of the 1000-hour draw.

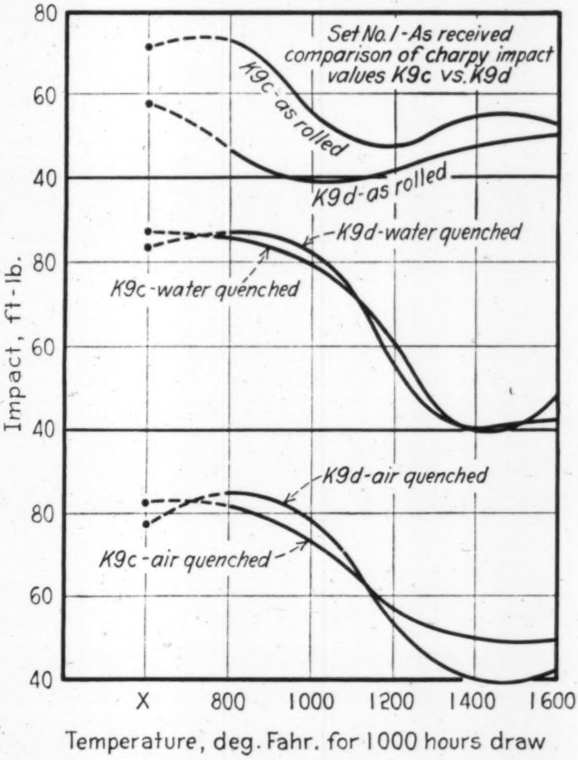

FIG. 6.—Average Curves Showing Relative Impact Strengths of Materials K9c and K9d Having Same Initial Treatment.

Summary:

1. Appreciable embrittlement of 18 per cent chromium, 8 per cent nickel steels with carbon content of 0.06 and 0.085 per cent is definitely produced after a 1000-hour draw at the temperature range 1000 to 1600° F. as revealed by the reduction of impact values in Charpy notched-bar tests.

2. For the period of 1000 hours there is a definite critical range in which the maximum embrittlement of these steels occur. The location of the critical range depends upon the initial treatments, as-rolled, or quenched in water or air from 2100 and 1950° F., respectively.

3. Under the 1000-hour annealing condition the as-rolled materials show relatively greater reduction of impact values at the lower temperatures (1000 to 1300° F.) than do the water-quenched or air-quenched ones.

4. There is practically no difference in the impact value between the K9c and K9d steels before and after the 1000-hour treatment through the temperature range of 800 to 1600° F.

5. The actual value at the critical temperature range is about the same for specimens with different initial treatments. That is to say, that, even though the as-rolled steel has a lower initial impact value than have the quenched specimens, the percentage of embrittlement in the former case is accordingly less than in the latter cases.

6. A brief anneal at 1600° F. followed by air cooling of specimens which had been annealed for a long time in the temperature range 800 to 1600° F. definitely recovers fully or partially their original impact strengths. The extent of this recovery depends on the initial treatments and the temperature of the long-time treatment. In other words, the as-rolled material shows complete recovery while the water-quenched or air-quenched material shows full recovery at the lower temperature and partial recovery in the higher range.

7. Under the above conditions of treatment, the K9c (0.06 per cent carbon) behaved practically the same as the K9d steel (0.085 per cent carbon).

Remarks:

While this report presents definite and significant results for the 18 per cent chromium, 8 per cent nickel steels which had undergone definite treatments, the full significance of the results will not be evident until they can be correlated with the results of other types of tests, each of which represents one phase of the conditions to which the materials are subjected.

This Charpy notched-bar test made at room temperature upon specimens treated under very well controlled temperatures and a simple atmosphere, is, of course, the necessary starting point in this study of embrittlement. It may not tell the whole story for the actual service conditions under which these steels are often used. Further impact tests might perhaps well be made on specimens subjected, for example, to steam or oil vapor at the temperatures under which the steel is used.

Respectfully submitted on behalf of Subcommittee G,

C. L. KINNEY, JR.,
Chairman.

MAGNETIC PERMEABILITY TESTS OF 18 PER CENT CHROMIUM, 8 PER CENT NICKEL, STAINLESS STEELS

The materials studied were designated as K9c and K9d, and were the same as those studied in the impact tests reported by Subcommittee G also appended to the Joint Committee report. The former contained 0.06 per cent carbon, and the latter 0.085 per cent. Both compositions were tested in the as-rolled condition, water quenched from 2100° F. and air quenched from 1950° F. These six lots were then annealed for 1000 hours at 800, 1000, 1200, 1400 and 1600° F., respectively. These and the comparison specimens that were not annealed, making 36 specimens in all, were subjected to magnetic permeability tests. Two sets of tests were made on identical specimens at different laboratories, as follows:

Table I.—Results of Permeability Tests on K9c and K9d Material.

Treatment of Material	K9c Material 0.06 per cent Carbon		K9d Material 0.085 per cent Carbon	
	Permeability		Permeability	
	At 500 Gausses	At 200 Gausses	At 500 Gausses	At 200 Gausses
As rolled, no anneal	1.0095	1.012	1.029	1.042
As rolled, annealed 1000 hours at 800° F.	1.0071	1.012	1.038	1.053
As rolled, annealed 1000 hours at 1000° F.	1.064	1.086	1.052	1.066
As rolled, annealed 1000 hours at 1200° F.	1.0190	1.022	1.023	1.039
As rolled, annealed 1000 hours at 1400° F.	1.0048	1.013	1.019	1.045
As rolled, annealed 1000 hours at 1600° F.	1.0071	1.007	1.0048	1.005
Water quenched from 2100° F., no anneal	1.030	1.060	1.026	1.052
Water quenched, annealed 1000 hours at 800° F.	1.026	1.047	1.020	1.032
Water quenched, annealed 1000 hours at 1000° F.	1.121	1.206	1.0095	1.027
Water quenched, annealed 1000 hours at 1200° F.	1.472	1.923	1.215	1.409
Water quenched, annealed 1000 hours at 1400° F.	1.252	1.475	1.079	1.099
Water quenched, annealed 1000 hours at 1600° F.	1.024	1.043	1.0107	1.013
Air quenched from 1950° F., no anneal	1.017	1.027	1.029	1.043
Air quenched, annealed 1000 hours at 800° F.	1.020	1.032	1.019	1.032
Air quenched, annealed 1000 hours at 1000° F.	1.168	1.213	1.017	1.024
Air quenched, annealed 1000 hours at 1200° F.	1.850	2.616	1.342	1.655
Air quenched, annealed 1000 hours at 1400° F.	1.066	1.080	1.021	1.026
Air quenched, annealed 1000 hours at 1600° F.	1.022	1.039	1.017	1.021

One set of tests, at 200 gausses was made by V. W. Van Epps under the direction of C. A. Scharschu in the laboratory of the Allegheny Steel Co. Mr. Scharschu describes the tests as follows:

The equipment used was a General Electric type *LC* form *C* permeameter. The equipment is essentially a modified Burroughs permeameter, having a magnetizing force or H factor of $10H$ per ampere per layer for the magnetizing coil. The solenoid which surrounds the test specimen has 100 turn induction (B) coil wound concentrical with it, so that it also encloses the test specimen. There is another coil so constructed, that while it is surrounded by the solenoid it does not enclose the test specimen. This coil is connected in series with the B coil, so that the potential developed in it bucks the potential of the B coil. This compensating coil is adjusted so that with no sample in the permeameter no deflection of the galvanometer is obtained upon a reversal of current in the magnetizing coil. Since the induction, B is equivalent to the magnetizing force, H, in air, whatever the value of H, this condition is always fulfilled with no sample in the solenoid. Thus the flux due to the area enclosed by the solenoid is not measured and all deflections of the galvanometer are proportional to only the intrinsic flux of the specimen. The B circuit is calibrated in the usual manner by a mutual inductor.

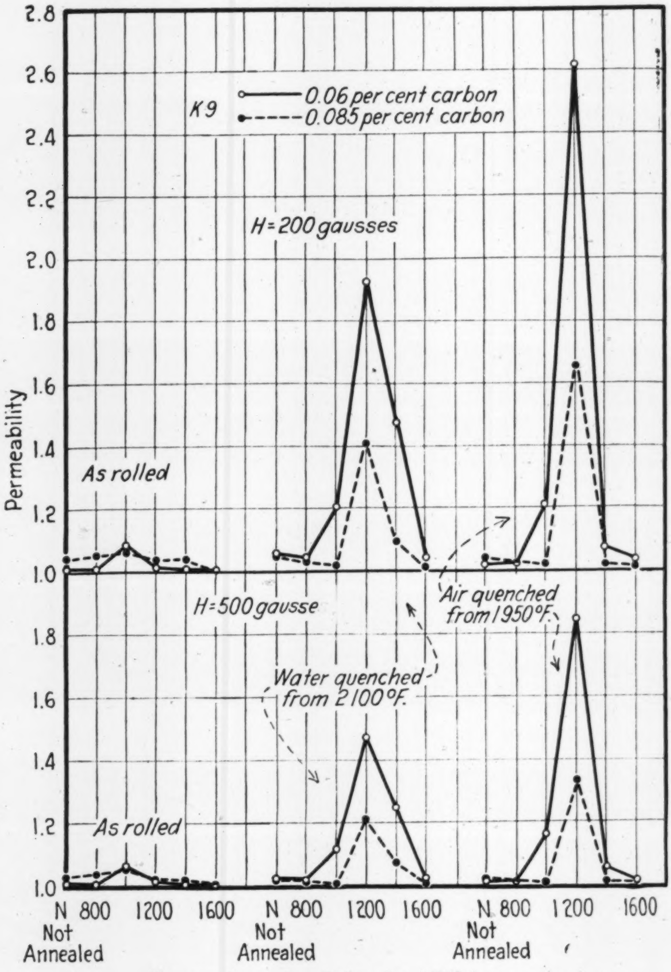

FIG. 1.—Magnetic Permeability Tests of K9c and K9d Materials.

Another set of tests at 500 gausses was made by S. L. Burgwin under the direction of T. D. Yensen at the laboratory of the Westinghouse Electric and Manufacturing Co. The following comments are made by Mr. Yensen:

> All 36 bars received were found to be almost non-magnetic. Consequently instead of the Fahy permeameter a more suitable test was used.
>
> In this test the bar is inserted in a solenoid with a field of approximately 500 gausses. A search coil with a large number of turns is permanently mounted at the mid-point of the solenoid and connected to a calibrated ballistic galvanometer. Thus, when the bar is removed from the field, the galvanometer gives a deflection proportional to the ferric induction of the sample and the permeability may be calculated. Of course, an error due to the demagnetizing effect of the ends of the bar is introduced. However, this error is small if the permeability is very low and may be neglected. The error due to residual induction is also negligible.
>
> The accuracy of these results is estimated to be within ± 10 per cent of $(\mu - 1)$ in the worst case. In general, the error is less for the lower permeabilities and higher for the higher permeabilities.

The data are shown in Table I and are plotted in Fig. 1. The "critical ranges" as shown by the permeability are in fair agreement with those found by the impact tests.

The main object of securing magnetic permeability data was for correlation of permeability with corrosion rate, since at the time this work was outlined there was controversy as to the existence of a relation between permeability and corrosion.

No conclusions can be drawn on this score till the corrosion tests have been completed and reported. The permeability data are, however, reported at this time for correlation with the impact data.

STRUCTURAL STABILITY OF 18 PER CENT CHROMIUM, 8 PER CENT NICKEL STAINLESS STEELS AT ELEVATED TEMPERATURES IN THE ABSENCE OF STRESS

REPORT OF SUBCOMMITTEE M COMPILED BY MR. LOUIS JORDAN

Materials and Cooperators:

Subcommittee M on Structural Stability received from Committee III on Technical Projects of the Joint Research Committee on Effect of Temperature on the Properties of Metals specimens of two 18 per cent chromium, 8 per cent nickel, stainless steels, one designated as K9c containing 0.06 per cent carbon, the other designated as K9d containing 0.085 per cent carbon. The nickel content of K9d was lower and the silicon content higher than in K9c. See the impact report[1] for analyses of both materials. A complete set of specimens of each of these steels consisted of 18 samples: namely, the steel as rolled and the "as rolled" specimens annealed for 1000 hours at each of five temperatures (6 samples); the steel as water quenched from 2100° F., and water-quenched specimens annealed for 1000 hours at each of the same five temperatures (6 samples); the steel as air quenched from 1950° F. and air-quenched specimens annealed for 1000 hours at each of the same five temperatures (6 samples). The temperatures of the 1000-hour annealing treatments were in all cases 800, 1000, 1200, 1400 and 1600° F. The specimens received by Subcommittee M were pieces $\frac{5}{8}$ in. square by $2\frac{1}{4}$ in. in length.

Subcommittee M was requested to study the structures of one set of each of the two 18 per cent chromium, 8 per cent nickel steels in the as-received condition, that is, as described in the preceding paragraph. The subcommittee was further requested to normalize at 1600° F. complete sets of each of the two steels, by heating for 3 hours at 1600° F. followed by cooling in air, and to compare the structures of the "normalized" sets with the "as-received" sets.

In accordance with this program two sets (18 specimens per set) of each of the two steels, K9c and K9d, were distributed to each of four cooperating laboratories from the membership of Subcommittee M. The laboratories and individuals thus actively assisting in this work were as follows:

The Babcock & Wilcox Tube Co.—H. D. Newell, Clark Church.
Battelle Memorial Institute—O. E. Harder, Samuel Epstein.
University of Minnesota—R. L. Dowdell, A. C. Forsyth, H. S. Jerabek, C. H. Green.
U. S. Bureau of Standards—Louis Jordan, S. E. Sinclair.

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[1] See p. 156.—ED.

Metallographic Examination:

Of the four cooperating laboratories one prepared micrographs of all specimens at a magnification of 200, two at a magnification of 500, and one at a magnification of 1000. In two laboratories the etching reagent was a glycerin solution of aqua regia and acetic acid (3 parts glycerin, 2 parts hydrochloric acid, 1 part nitric acid, 1 part acetic acid); in another laboratory aqua regia diluted with water and with a slight addition of ferric chloride; in the fourth laboratory a hydrochloric acid - chromic acid mixture (5 parts of concentrated hydrochloric and 1 part of 10-per-cent aqueous chromic acid solution).

Table I gives a composite description of the structural phases of the specimens based on the reports and the micrographs of all four of the cooperating laboratories. Figures 1 and 2 illustrate, at a magnification of 200 diameters, the differences in grain size between the as-rolled and the water-quenched or air-quenched specimens. Figure 3 shows that a rolled structure of elongated grains existed in the as-rolled higher carbon steel (K9d), persisted throughout the 1000-hour annealing treatments at the lower temperatures, and was eliminated by recrystallization only after the annealing treatments at 1400 and 1600° F. An entirely similar condition existed in the specimens of this material (K9d as rolled) after the supplementary 3-hour normalizing treatment at 1600° F. except that a slight tendency towards recrystallization was first evident in the normalized specimen which had received the 1000-hour annealing at 1200° F. Other than these two features, namely, the differences in grain size in the several materials and the persistence of a rolled structure in the K9d steel, all other structural characteristics are illustrated in the micrographs of Figs. 4 to 11.

Only three structural constituents are evident in the specimens examined, namely, (1) austenite; (2) carbides, presumably of rather complex composition; and (3) a magnetic decomposition product of the austenite which is designated in this report simply as ferrite. This latter constituent is assumed to contain iron, nickel, and chromium.

Lower Carbon Steel (K9c).—The lower carbon steel in the as-received condition, whether as rolled, water quenched, or air quenched, showed the first precipitation of carbides (as fine particles and restricted to the grain boundaries) after the 1000-hour annealing treatment at 1000° F. These carbides were very markedly fewer in number, however, in the water-quenched and air-quenched specimens than in the as-rolled specimens. Agglomeration of the finer carbide particles was first evident in the as-rolled series after the 1200° F.

TABLE I.—COMPOSITE DESCRIPTION OF STRUCTURAL PHASES OF K9c AND K9d STEELS.

NOTE.—R = As Rolled. WQ = Water Quenched. AQ = Air Quenched.

Material	Treatment	Set No. 1: Specimens Examined After Heat Treatments Shown Below						Set No. 2: Specimens Examined After Normalizing Treatment (3 hours at 1600° F. and air cooled) Subsequent to Heat Treatments Shown Below					
		As Rolled, Water Quenched, or Air Quenched	1000-Hour Draw					As Rolled, Water Quenched, or Air Quenched	1000-Hour Draw				
			At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.		At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.
		X	A	B	C	D	E	X	A	B	C	D	E
K9c (0.06 per cent Carbon)	R....	Small grained austenite. No precipitated phase.	Same as K9c–R–X.	Fine carbides precipitated at grain boundaries.	Increased amount of precipitated carbides, still outlining grains. Slight agglomeration of carbides.	Agglomeration of precipitated carbides increased so that grains not completely outlined.	Very similar to specimen K9c-R-D.	Fine grains partly outlined by considerably agglomerated carbides.	Same as normalized K9c-R-X.	Same as normalized K9c-R-A.	Same as normalized K9c-R-B except carbide outline of grains very faint.	Finer carbide particles no longer present; coarse carbides remain; no outline of grains by carbides.	Same as normalized K9c-R-D.
	WQ..	Large grained austenite. No precipitated phase.	Same as K9c–WQ–X.	Slight precipitation of carbides at grain boundaries. Also precipitation of ferrite at grain boundaries.	Increased precipitation of carbides completely outlining grains. Precipitation of ferrite within some grains.	Slight agglomeration of carbides at boundaries. Precipitation of carbides on twinning planes and within grains. Ferrite no longer apparent.	Marked agglomeration of carbides both at boundaries, on twinning planes, and within grains.	Large grains completely outlined with agglomerated carbides.	Same as normalized K9c-WQ-X.	Similar to normalized K9c-WQ-A; also few fine carbides precipitated near grain boundaries.	Precipitation fine carbides at borders of grains very pronounced, that is, widened grain boundaries.	Fine carbides at grain borders absent; agglomerated carbides both at grain boundaries on twinning planes and within grains.	Very similar to K9c-WQ-D with carbides possibly in slightly larger particles.
	AQ..	Large grained austenite. No precipitated phase.	Same as K9c-AQ-X.	Slight precipitation of carbides at grain boundaries. Also precipitation of ferrite at grain boundaries.	Increased precipitation of carbides at grain boundaries. Precipitation of ferrite within some grains.	Boundaries completely outlined with precipitated carbides. Also carbides within grains. Agglomeration of carbides beginning.	Agglomeration of carbides has progressed at boundaries. Few carbides within grains.	Large grains distinctly outlined with rather coarsely agglomerated carbides.	Same as normalized K9c-AQ-X.	Similar to normalized K9c-AQ-A; additional carbides precipitated at grain boundaries.	Increased agglomeration of carbides at grain boundaries.	Coarse carbides forming broken outlines of grains.	Similar to normalized K9c-AQ-D. Carbide particles possibly even larger.

TABLE I.—*Continued.*

NOTE.—R = As Rolled. WQ = Water Quenched. AQ = Air Quenched.

Material	Treatment	Set No. 1: Specimens Examined After Heat Treatments Shown Below						Set No. 2: Specimens Examined After Normalizing Treatment (3 hours at 1600° F. and air cooled) Subsequent to Heat Treatments Shown Below					
		As Rolled, Water Quenched, or Air Quenched	1000-Hour Draw					As Rolled, Water Quenched, or Air Quenched	1000-Hour Draw				
			At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.		At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.
		X	A	B	C	D	E	X	A	B	C	D	E
K9d (0.085 per cent Carbon)	R....	Small grained austenite. A few carbides at grain boundaries. Grains markedly elongated from rolling.	Same as K9d-R-X.	Increased amount of carbides at grain boundaries. Grains still elongating from rolling.	Precipitated carbides completely outline grains. Some carbides precipitated within grains. Rolled structure persists.	Agglomeration of precipitated carbides both at boundaries and within grains. Recrystallization has removed rolled structure.	Agglomeration of carbides has distinctly increased.	Fine grains outlined by well agglomerated carbides. Grains elongated from rolling.	Same as normalized K9d-R-X.	Same as normalized K9d-R-A.	Same as normalized K9d-R-B. Slight indication of recrystallization of rolled structure.	Carbides are coarser; recrystallization has removed rolled structure.	Same as normalized K9d-R-D.
	WQ..	Large austenite grains. No precipitated carbides.	Same as K9d-WQ-X.	Beginning precipitation at grain boundaries.	Increased precipitation of carbides at boundaries and twinning planes and slight amount within grains near boundaries.	Agglomeration of precipitated carbides at boundaries; increased amount of precipitated carbides within the grains.	Agglomeration increased with an abundance of precipitated carbides within the grains.	Large grains outlined by agglomerated carbides.	Same as normalized K9d-WQ-X.	Carbide precipitation in grain boundaries increased. Also precipitation carbides on twinning planes.	Carbides appear within grains, particularly near grain borders.	Precipitated and well agglomerated carbides at grain boundaries and within grains.	Similar to normalized K9d-WQ-D; still greater agglomeration of carbides.
	AQ..	Large austenite grains. No precipitated carbides.	Same as K9d-AQ-X.	Beginning of carbide precipitation at grain boundaries.	Increased precipitation of carbides at boundaries and twinning planes; a few carbides precipitated within grains.	Agglomeration of precipitated carbides at grain boundaries; increased amount of precipitated carbides within grains.	Agglomeration of carbides increasing both at boundaries and within grains.	Large grains outlined by agglomeration of carbides; also carbides precipitated on twinning planes.	Carbides precipitated at grain boundaries have increased.	Marked agglomeration of carbides at grain boundaries.	Similar to normalized K9d-AQ-B; fine carbides begin to precipitate within grains.	Carbides precipitated within grains are increased; and agglomerated.	Same as normalized K9d-AQ-D.

anneal. The 1200° F. annealing treatment in the water-quenched and air-quenched series resulted only in increased precipitation of carbides and no agglomeration. Agglomeration of carbides in the water-quenched and air-quenched series was evident after the 1400° F. annealing treatment.

The water-quenched and air-quenched specimens of the K9c steel annnealed at 1000 and 1200° F. contain ferrite, the specimens annealed at 1000° F. showing the ferrite only at grain boundaries and the specimens annealed at 1200° F. having ferrite also within the austenite grains. In this latter case the ferrite exhibits striking and apparently characteristic "feather-like" or "spear-head" formations (specimen K9c-WQ-C, set No. 1, Table I and Fig. 4).

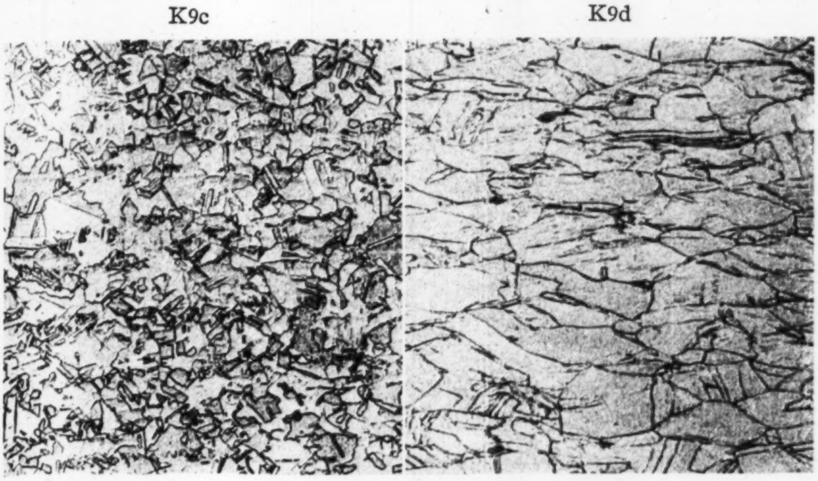
TABLE II.—MAGNETIC PROPERTIES OF K9c AND K9d STEELS IN THE AS-RECEIVED CONDITION.

NOTE.—R = As Rolled. WQ = Water Quenched from 2100° F. AQ = Air Quenched from 1950° F. N = Non-magnetic. S = Slightly magnetic. M = Magnetic. VS = Very Slightly Magnetic.

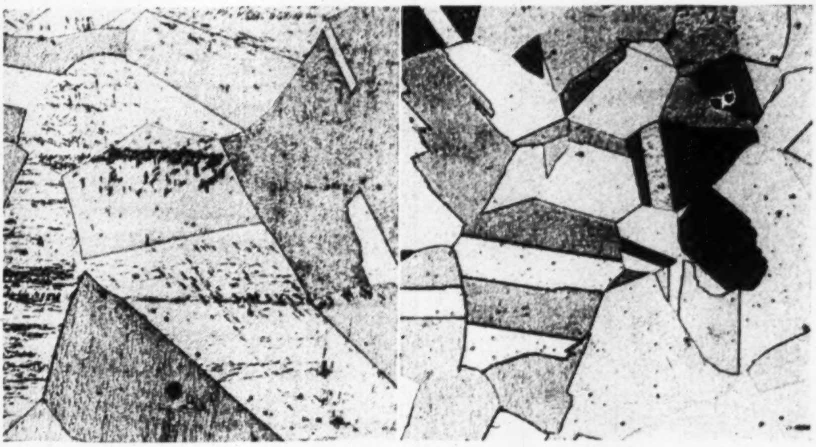
Material	Treatment	As Rolled, Water Quenched or Air Quenched	1000-Hour Draw				
			At 800° F.	At 1000° F.	At 1200° F.	At 1400° F.	At 1600° F.
		X	A	B	C	D	E
K9c (0.06 per cent Carbon)..........	R..........	N	N	N	N	N	N
	WQ........	N	N	S	M	M	N
	AQ........	N	N	VS	M	VS	N
K9d (0.085 per cent Carbon)..........	R..........	N	N	N	N	N	N
	WQ........	N	N	N	S	N	N
	AQ........	N	N	N	M	N	N

As a further means of determining in which specimens this ferrite phase was present, one of the cooperators tested the magnetic qualities of the etched surface of each of his metallographic specimens by determining its attraction for a steel needle suspended within the field of a strong permanent magnet. These observations are recorded in Table II. They indicate the presence of the magnetic phase (ferrite) in the K9c (as-received) specimens annealed at 1000 and 1200° F. in both water-quenched and air-quenched conditions, thus checking the results of the metallographic examinations. This magnetic test, however, indicated the presence of the ferrite phase in the specimens of these same two series (water quenched and air quenched) annealed at 1400° F. Metallographic examinations had not shown ferrite in either of these two latter specimens.

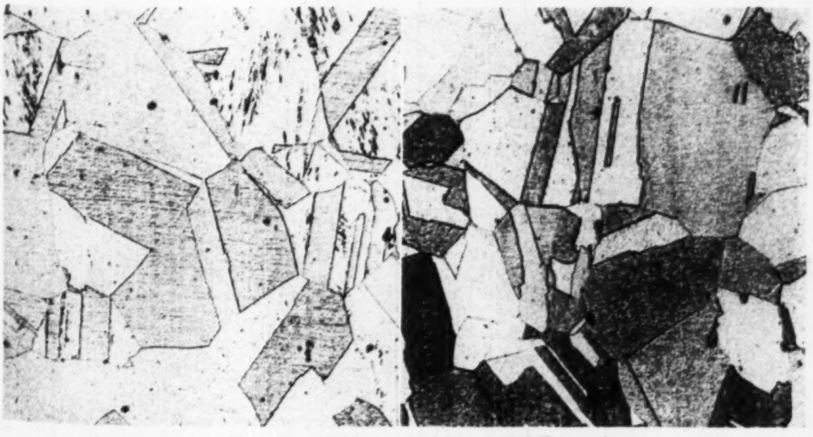
The low-carbon steel in the normalized condition (Table I, set No. 2, 3 hours at 1600° F. and air cooled) showed grains distinctly



X specimen, as rolled.

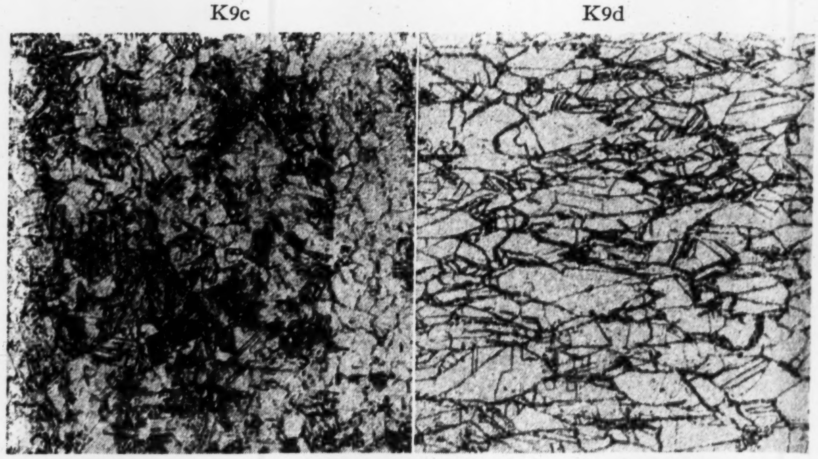


X specimen, water quenched from 2100° F.

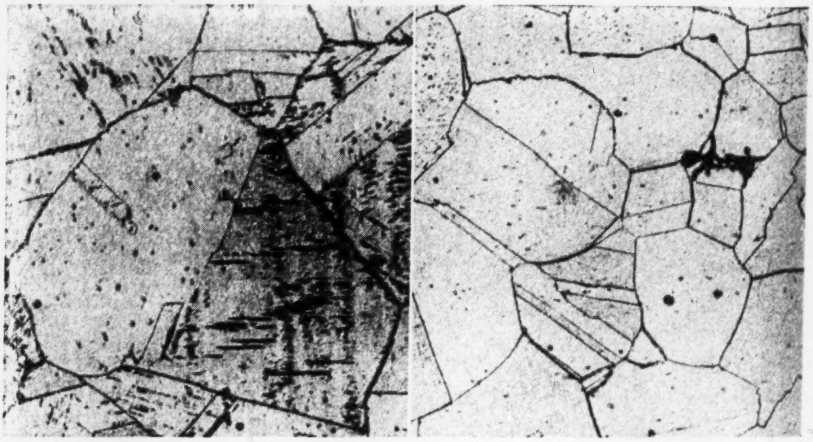


X specimen, air quenched from 1950° F.

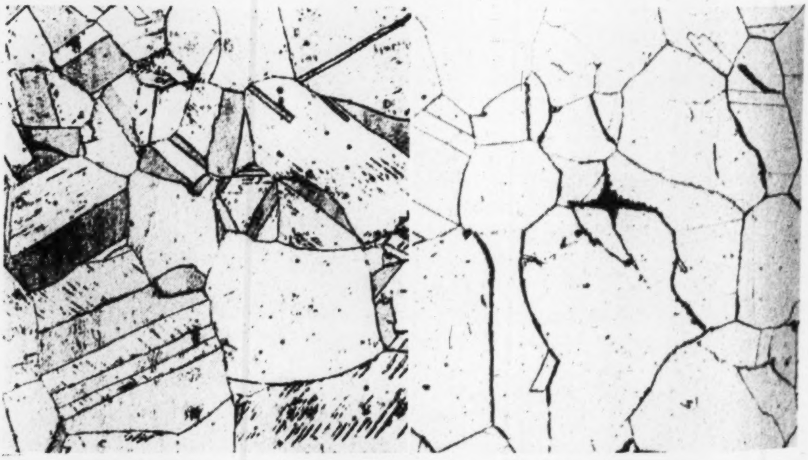
FIG. 1.—Comparative Grain Size of K9c and K9d, "As-Received" (× 200).



X specimen, as rolled.

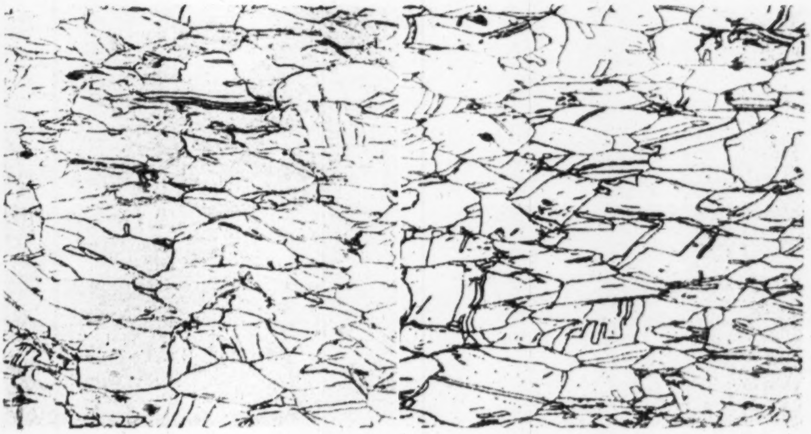


X specimen, water quenched from 2100° F.



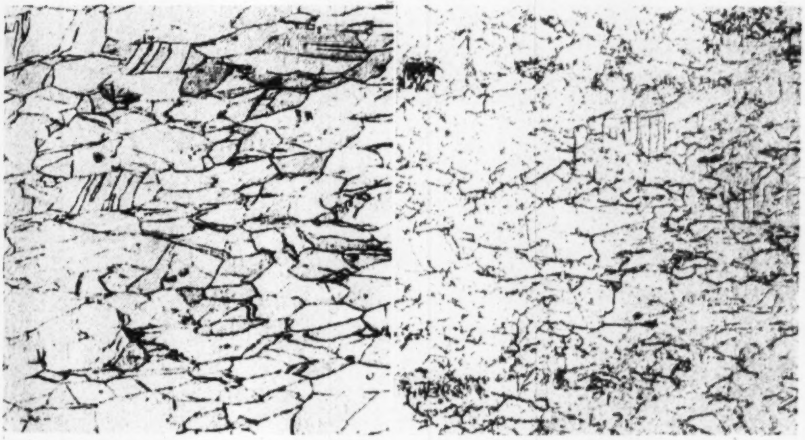
X specimen, air quenched from 1950° F.

FIG. 2.—Comparative Grain Size of K9c and K9d After Normalizing at 1600° F. for 3 Hours (× 200).



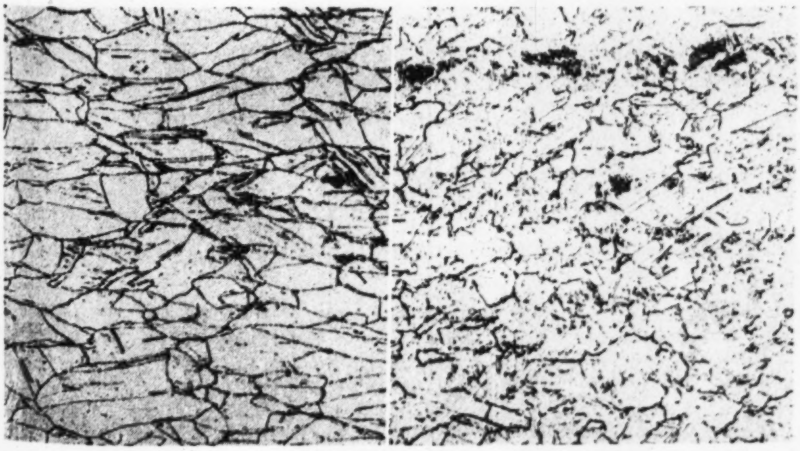
X specimen, as rolled.

C specimen, 1000-hour draw at 1200° F.



A specimen, 1000-hour draw at 800° F.

D specimen, 1000-hour draw at 1400° F.



B specimen, 1000-hour draw at 1000° F.

E specimen, 1000-hour draw at 1600° F.

FIG. 3.—As Rolled Structure of K9d, "As-Received" (× 200).

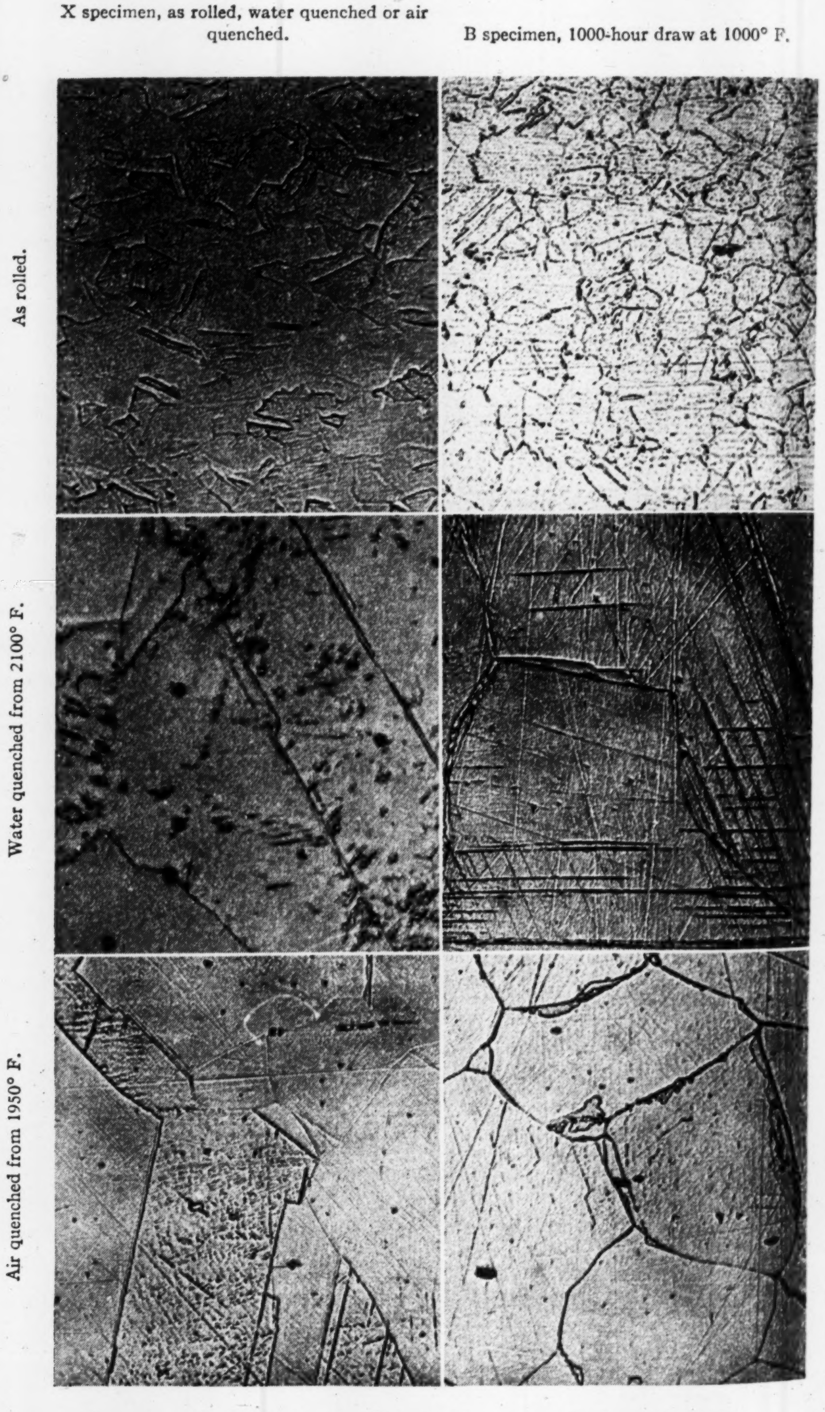
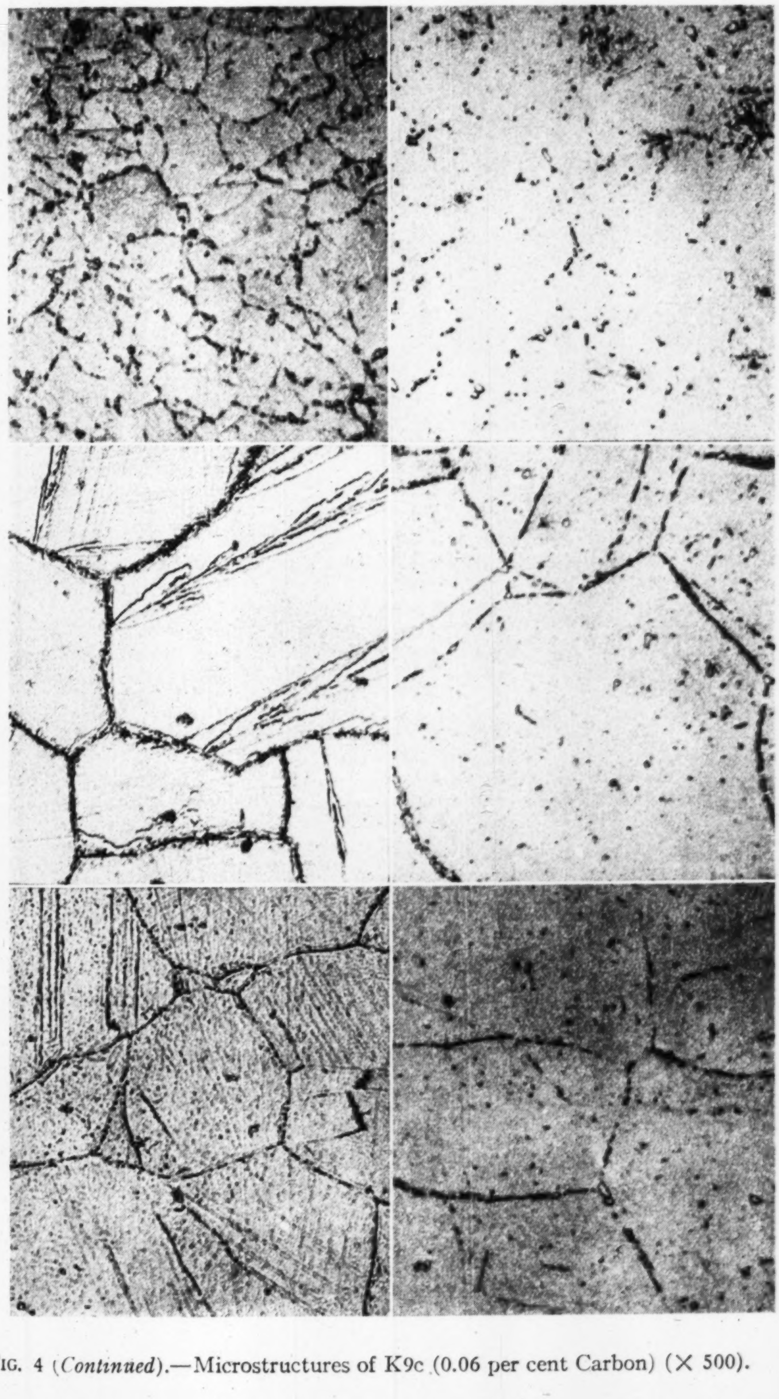

X specimen, as rolled, water quenched or air quenched.
B specimen, 1000-hour draw at 1000° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 4.—Microstructures of K9c (0.06 per cent Carbon) (× 500).



C specimen, 1000-hour draw at 1200° F.

E specimen, 1000-hour draw at 1600° F.

As rolled.

Water quenched from 2100° F.

Air quenched from 1950° F.

FIG. 4 (*Continued*).—Microstructures of K9c (0.06 per cent Carbon) (× 500).

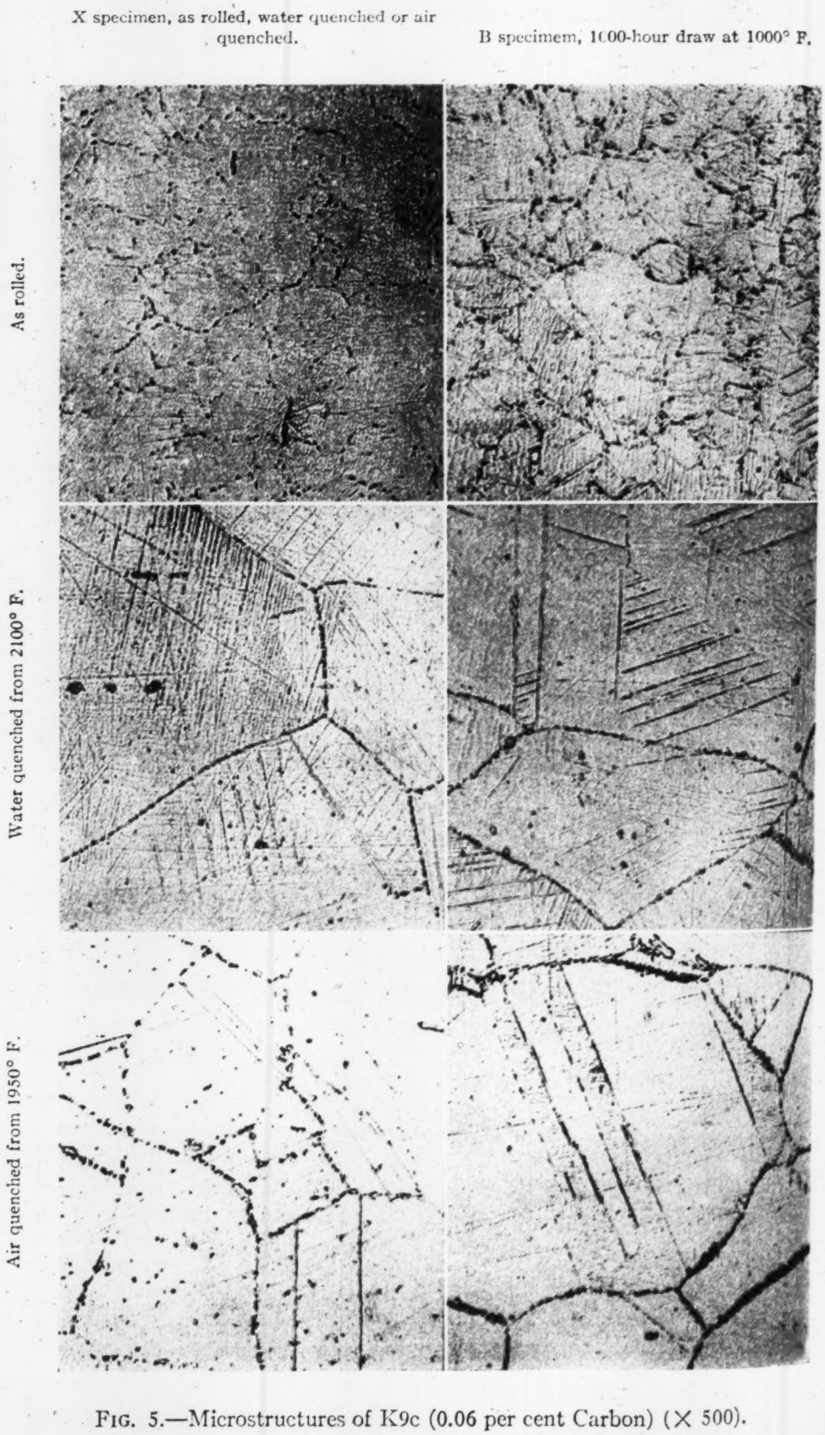

X specimen, as rolled, water quenched or air quenched.
B specimem, 1000-hour draw at 1000° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 5.—Microstructures of K9c (0.06 per cent Carbon) (× 500).
Specimens normalized 3 hours at 1600° F. after treatments shown.

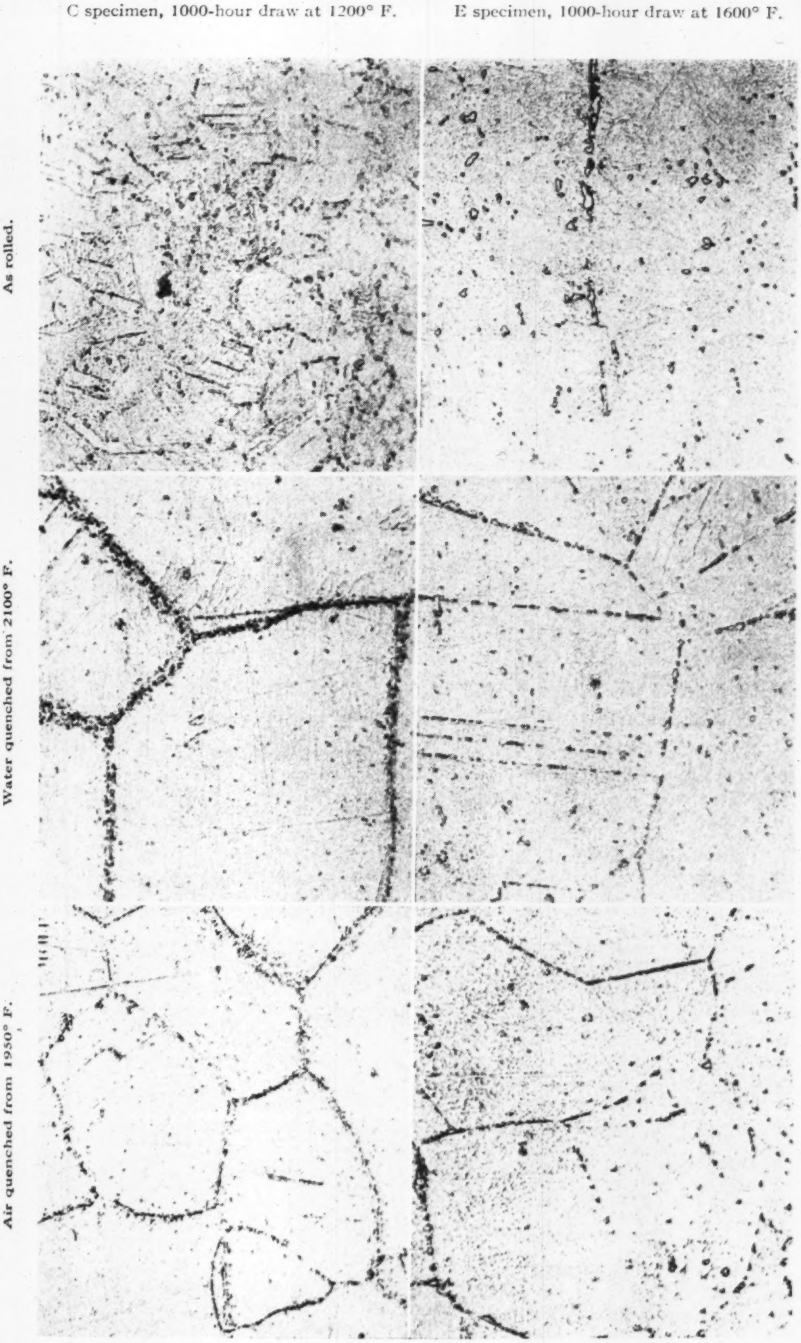
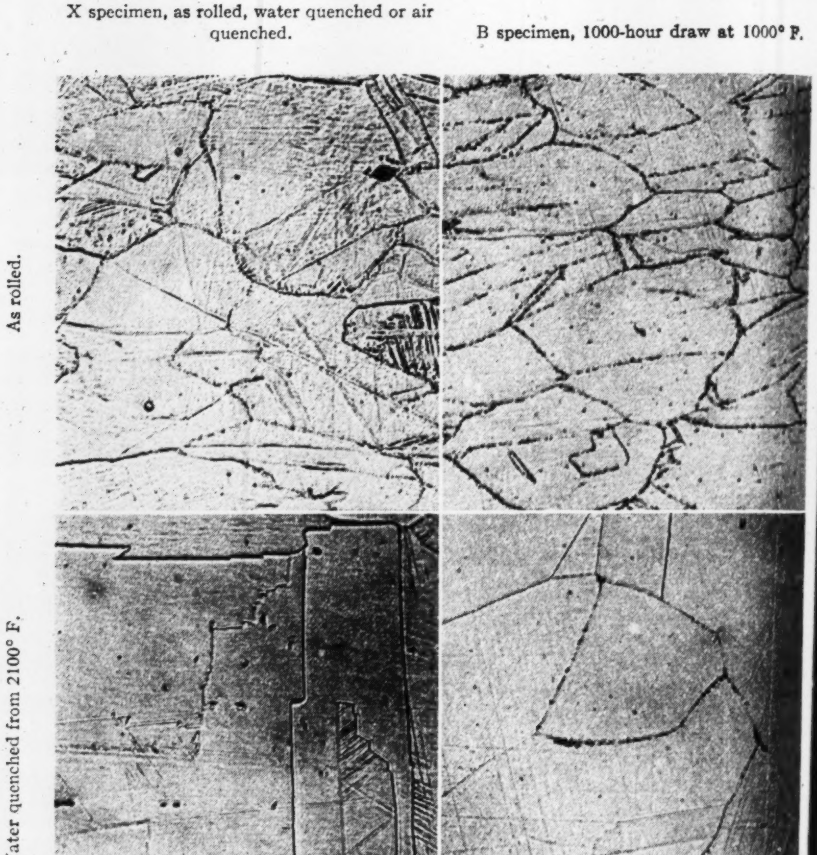

C specimen, 1000-hour draw at 1200° F.
E specimen, 1000-hour draw at 1600° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 5 (*Continued*).—Microstructures of K9c (0.06 per cent Carbon) (× 500).

Specimens normalized 3 hours at 1600° F. after treatments shown.



X specimen, as rolled, water quenched or air quenched.

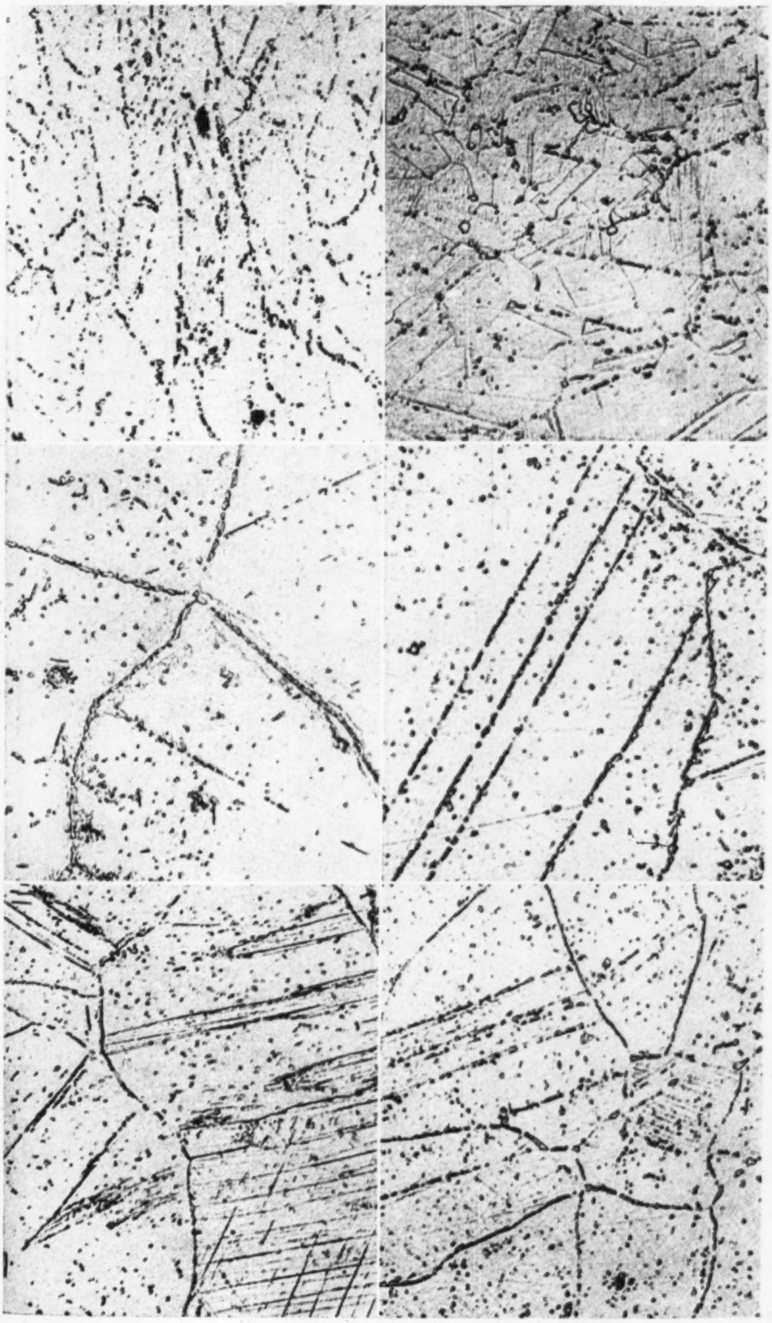
B specimen, 1000-hour draw at 1000° F.

As rolled.

Water quenched from 2100° F.

Air quenched from 1950° F.

FIG. 6.—Microstructures of K9d (0.085 per cent Carbon) (× 500).



D specimen, 1000-hour draw at 1400° F.

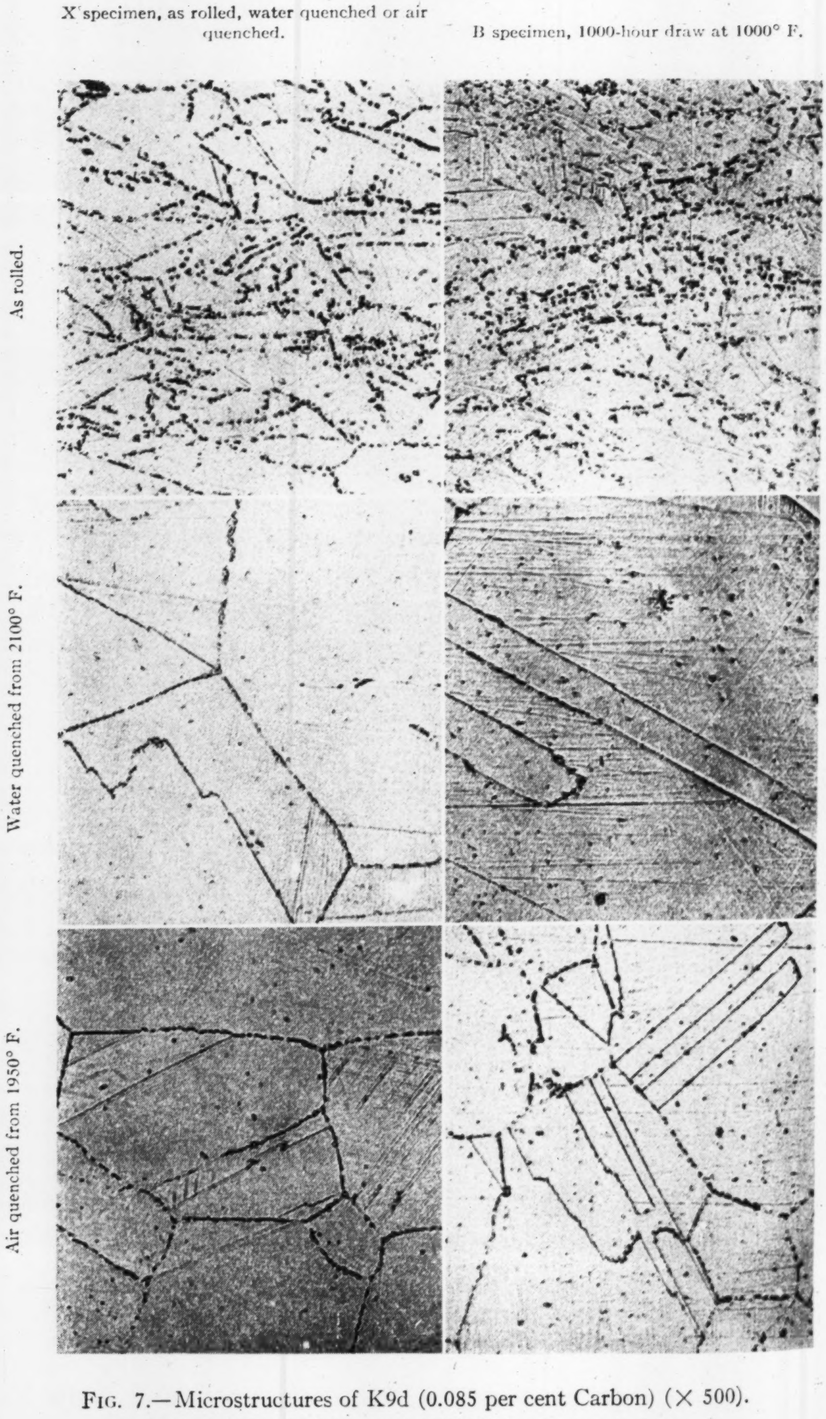
E specimen, 1000-hour draw at 1600° F.

As rolled.

Water quenched from 2100° F.

Air quenched from 1950° F.

FIG. 6 (*Continued*).—Microstructures of K9d (0.085 per cent Carbon) (× 500).



X specimen, as rolled, water quenched or air quenched.

B specimen, 1000-hour draw at 1000° F.

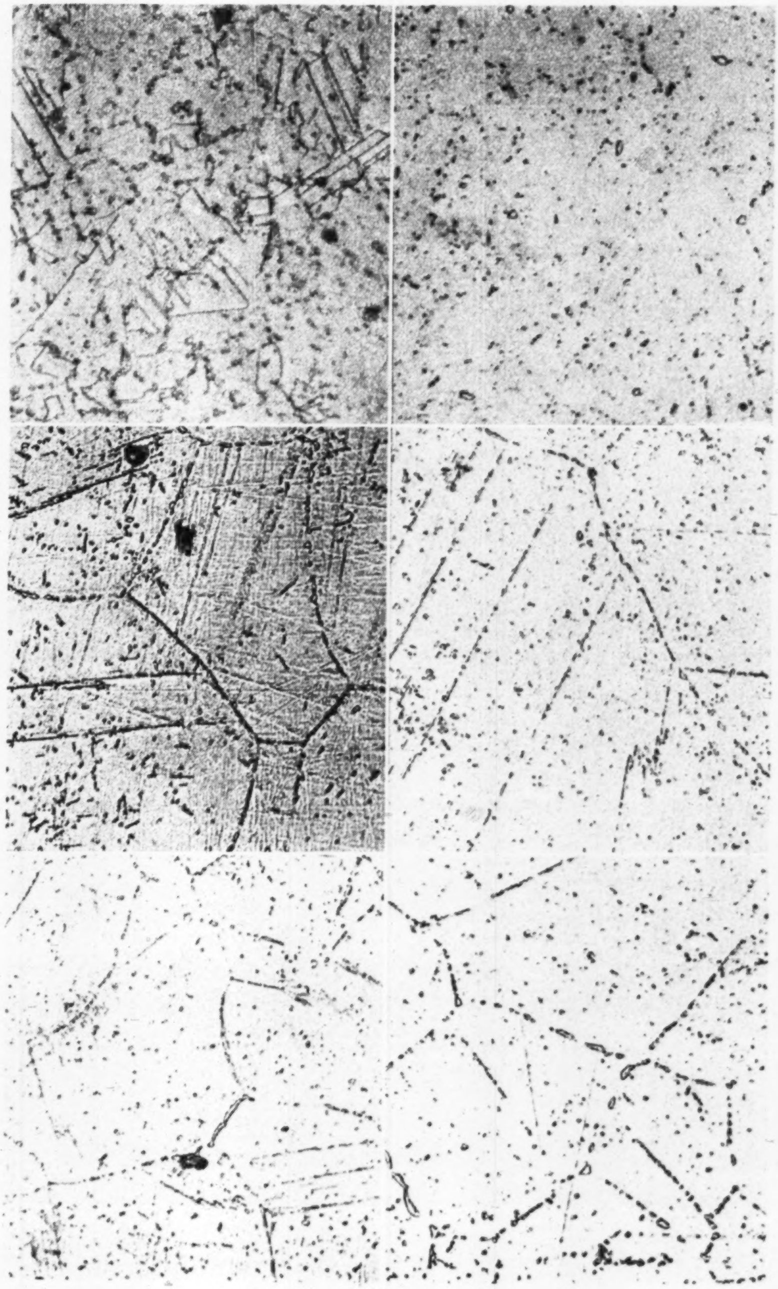
As rolled.

Water quenched from 2100° F.

Air quenched from 1950° F.

FIG. 7.—Microstructures of K9d (0.085 per cent Carbon) (× 500).
Specimens normalized 3 hours at 1600° F. after treatments shown.

D specimen, 1000-hour draw at 1400° F. E specimen, 1000-hour draw at 1600° F.



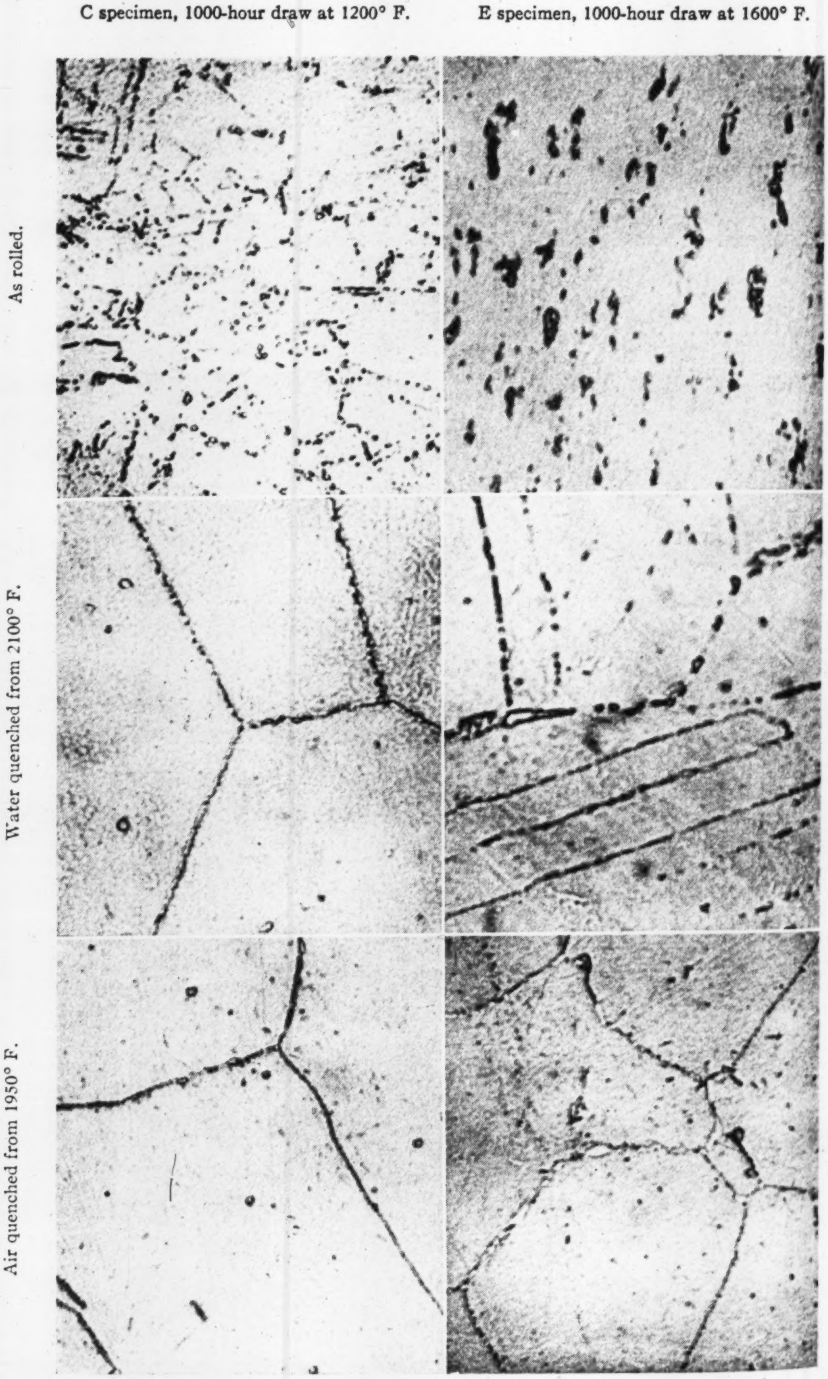
As rolled.

Water quenched from 2100° F.

Air quenched from 1950° F.

FIG. 7 (*Continued*).—Microstructures of K9d (0.085 per cent Carbon) (× 500).

Specimens normalized 3 hours at 1600° F. after treatments shown.



C specimen, 1000-hour draw at 1200° F.

E specimen, 1000-hour draw at 1600° F.

As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 8.—Microstructures of K9c (0.06 per cent Carbon) (× 1000).

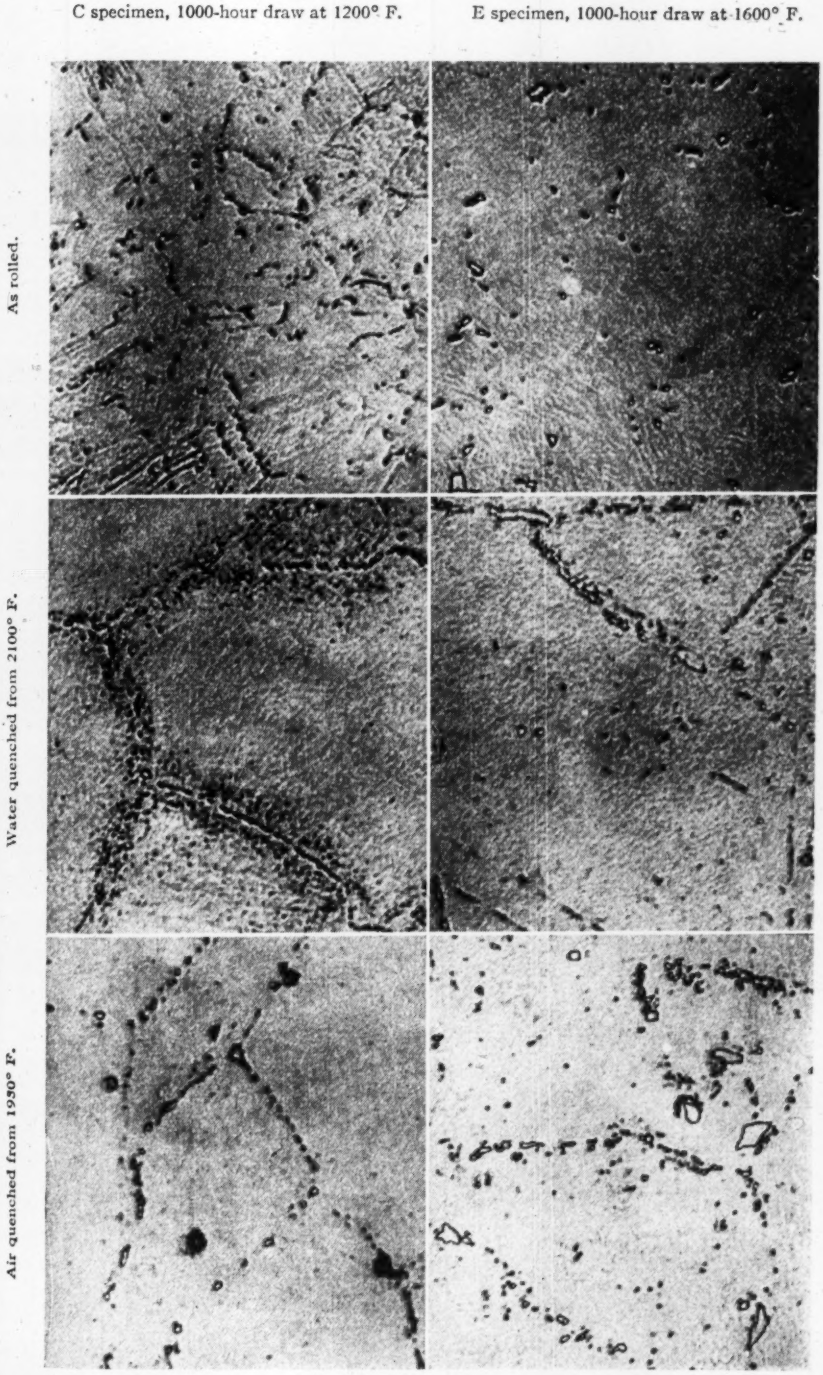

C specimen, 1000-hour draw at 1200° F.
E specimen, 1000-hour draw at 1600° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 9.—Microstructures of K9c (0.06 per cent Carbon) (× 1000).
Specimens normalized 3 hours at 1600° F. after treatments shown.

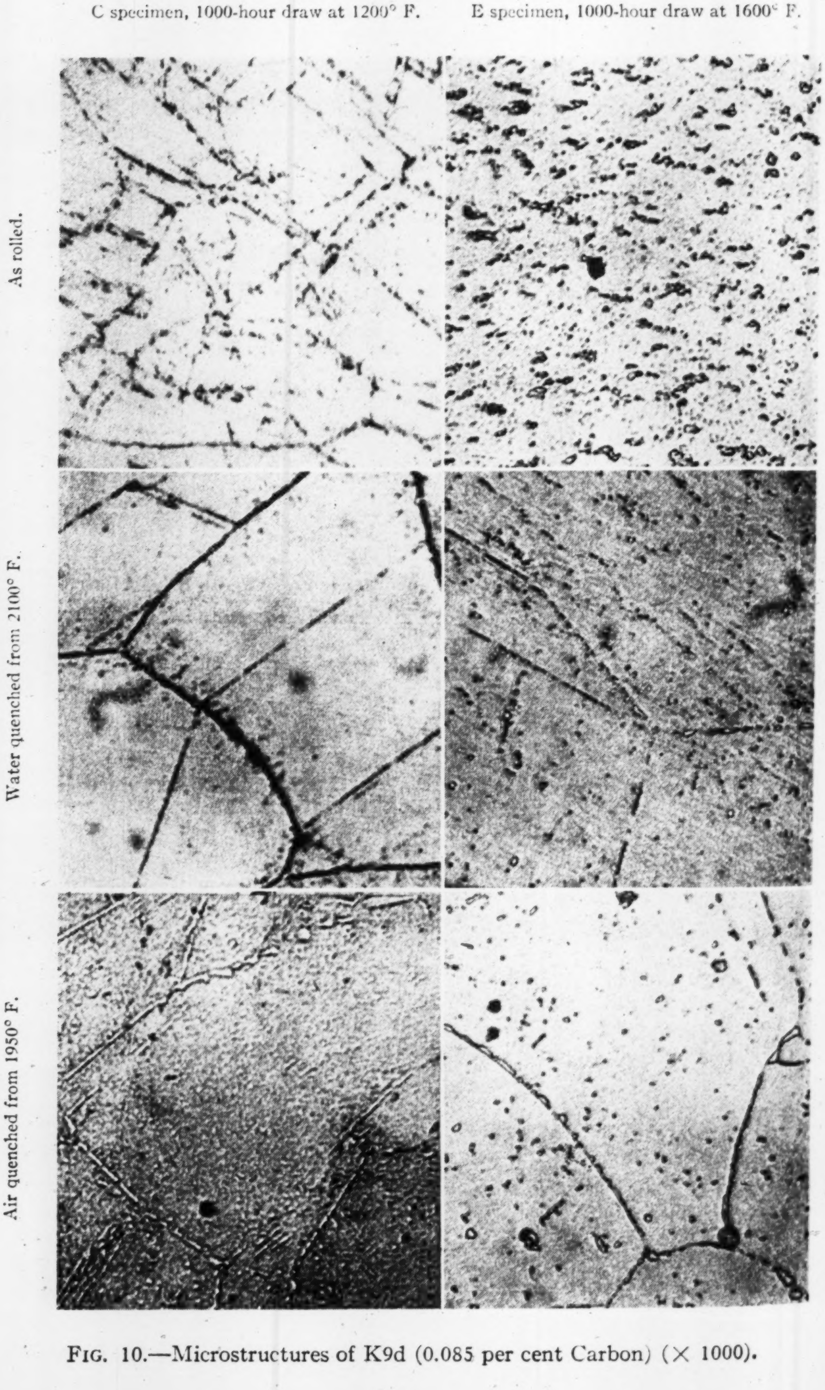

C specimen, 1000-hour draw at 1200° F.
E specimen, 1000-hour draw at 1600° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 10.—Microstructures of K9d (0.085 per cent Carbon) (× 1000).

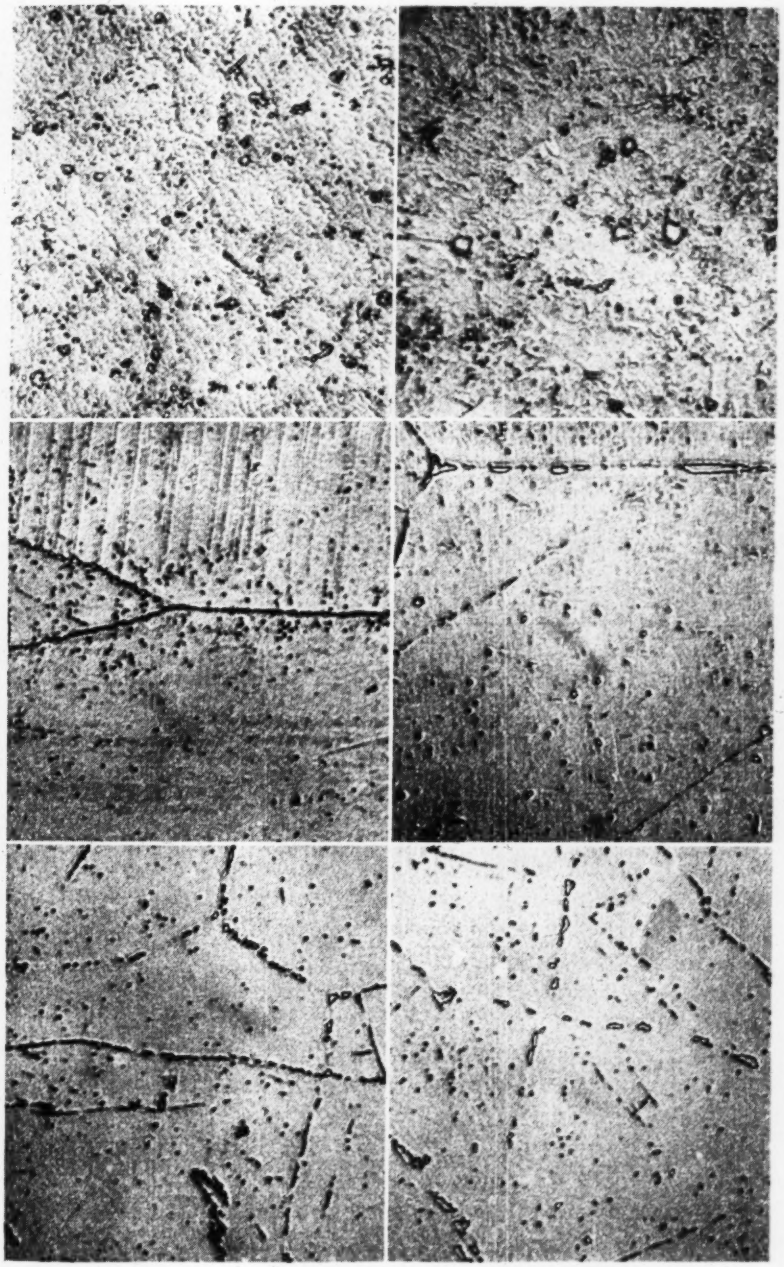

C specimen, 1000-hour draw at 1200° F.
E specimen, 1000-hour draw at 1600° F.
As rolled.
Water quenched from 2100° F.
Air quenched from 1950° F.

FIG. 11.—Microstructures of K9d (0.085 per cent Carbon) (× 1000).

Specimens normalized 3 hours at 1600° F. after treatments shown.

outlined with agglomerated carbides even in the as-rolled, water-quenched, and air-quenched specimens which had received no 1000-hour annealing treatment. The specimens of the as-rolled series showed continually increasing agglomeration of carbides as the temperature of the 1000-hour annealing treatment increased. At and above the annealing temperature of 1200° F. the outlines of the grains by the carbides was incomplete or indistinct. In the water-quenched and air-quenched series, however, progressive agglomeration of carbides was not the only factor. In addition there was a very evident additional precipitation of fine carbides near but not directly in the grain boundaries in the B and C specimens, that is specimens from annealing treatments at 1000 and 1200° F. The agglomeration of carbides at grain boundaries to such an extent as to make the grain outline incomplete, and the agglomeration of carbides within the grains was pronounced only in the D and E specimens of these two series, that is, specimens from annealing treatments at 1400 and 1600° F.

Higher Carbon Steel (*K9d*).—The higher carbon steel in the as-received condition (set No. 1, Table I) showed some few precipitated carbides in the as-rolled specimens but no carbides in the water-quenched or air-quenched specimens. The 1000-hour treatment at 800° F. caused no structural changes in any of these three series. After the 1000-hour anneal at 1000° F. additional precipitated carbides at grain boundaries were visible in the as-rolled series and the precipitation of carbides began at grain boundaries in the water-quenched and air-quenched series. In the C specimens (1200° F. anneal) precipitation of carbides within the grains began in all three series. Up to this point, the 1200° F. anneal, a rolled structure had persisted in all the specimens of the as-rolled series. At the 1400° F. anneal, agglomeration of carbides at grain boundaries was pronounced in all three series and the rolled structure had been eliminated from the as-rolled series specimen.

In the normalized specimens of the K9d steel (Table I, set No. 2, 3 hours at 1600° F. and air cooled) carbide precipitation increased in the X specimens (those without any 1000-hour anneal) of all three series as compared with the same specimens before normalizing.

The precipitated carbides were very numerous in the X specimen of the as-rolled series and there was but little change in structures of the succeeding specimens of this series except that the rolled structure (elongated grains) showed some modifications in the C specimen (1200° F. anneal) and had been eliminated in the D specimen (1400° F. anneal). Also, the carbide particles were noticeably coarser, more agglomerated, in the D and E specimens of the as-rolled series.

The structures of the normalized water-quenched and air-quenched series were quite similar. While, as already stated, the X specimens of these series showed carbide precipitation, the amount of carbide precipitation was rather small and confined to grain boundaries in the X, A, and B specimens. In the C specimens (1200° F. anneal) precipitation of carbides within the austenite grains first was evident. In the last two specimens of each series (D and E, 1400 and 1600° F. anneal, respectively) the carbides within the grains were both numerous and well agglomerated.

Conclusions:

The as-rolled series of both K9c and K9d steels were of distinctly smaller grain size than the water-quenched or air-quenched series of the same steels. The 1000-hour annealing treatments caused no significant changes in grain size except in the case of the K9d as-rolled series which in its original condition showed grains distinctly elongated in the direction of rolling. This rolled structure persisted in the 1000-hour annealing treatments at 800, 1000 and 1200° F. and was removed only by the 1400 and 1600° F. treatments. The possible significance of this condition in the K9d as-rolled series is emphasized for consideration in connection with the report of the impact tests[1] on these same steels. It seems likely that the departures of the curves for K9d as-rolled steel from what appears to be the normal course of the remaining curves of the impact report, may be correlated, at least in part, with this structural characteristic of the K9d as-rolled steel.

Both water-quenched and air-quenched specimens of K9c steel when annealed 1000 hours at 1000 or 1200° F. showed the presence of a magnetic constituent (ferrite). This ferrite was not detected in samples annealed at 1400 or 1600° F.

The higher carbon steel in the as-rolled condition showed the presence of a few precipitated carbides prior to any of the 1000-hour annealing treatments. The first precipitation of carbides appeared in all other specimens only after the 1000-hour treatment at 1000° F.

Carbides appear to precipitate first and most easily at grain boundaries and along twinning planes. At the higher annealing temperatures carbides precipitated generally throughout the grains and also agglomerated to larger particles. As agglomeration of carbides progressed at the higher temperatures the outline of grains by the carbides became broken or incomplete. This progression of precipitation and agglomeration was practically the same in both low-carbon and high-carbon steels in all three conditions, namely, as rolled, water quenched, and air quenched. The precipitation of carbides, however, began at a slightly lower temperature in the as-rolled steels as compared with either water quenched or air quenched; this precipitation also was more pronounced at the lower temperatures in the higher-carbon steel than in the lower-carbon steel.

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[1] See p. 156.—ED.

After the normalizing treatment of 3 hours at 1600° F. and cooling in air, precipitated and very noticeably agglomerated carbides were present in both steels at the grain boundaries of all specimens which had received no 1000-hour annealing treatment.

Throughout the normalized, as-rolled, series of the low-carbon steel there was very little difference in structure, except that in samples which had been annealed at or above 1200° F. the carbides were very coarse and did not completely outline the grains. Those specimens of the water-quenched and air-quenched K9c steel which showed magnetic ferrite after annealing at 1000 and 1200° F. showed after the normalizing treatment a pronounced widening of grain boundaries, that is, a precipitation of numerous fine carbides in a rather wide band along each side of the grain boundary proper.

The normalizing treatment noticeably increased the agglomeration of carbides throughout the entire as-rolled series of the higher carbon steel. Relatively slight differences in structure were evident in comparing the normalized water-quenched and air-quenched K9d steels with the same specimens before normalizing. Slightly increased agglomeration of the carbides and the consequent less complete outline of the grain boundaries in the B and C specimens (1000 and 1200° F. anneal) were the only readily detectable differences.

It is to be emphasized that this study of structural stability of 18 per cent chromium, 8 per cent nickel steels at elevated temperatures was made on specimens which were not subjected to stress while at the elevated temperatures.

Respectfully submitted on behalf of Subcommittee M,

LOUIS JORDAN,
Chairman.

REPORT OF COMMITTEE B-1
ON
COPPER WIRE

Committee B-1 on Copper Wire has held one meeting and is able to report success in the work of the joint committee, representing the American Railway Association, the American Electric Railway Engineering Association, and the American Society for Testing Materials, in the consideration of specifications for trolley wire both of copper and bronze which it is confidently expected will be accepted as the standard of all three associations. The specifications so recommended may be said to be relatively minor amendments of the A.S.T.M. Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 30) and for Bronze Trolley Wire (B 9 – 30).

The committee recommends that the Executive Committee of the A.S.T.M., when the two trolley wire specifications are amended, as proposed later in this report, take the necessary steps to put these specifications before the American Standards Association for approval as American Standards on the basis of the joint recommendation of the three societies participating in their adoption.

Acting as a Sectional Committee, functioning under the procedure of the American Standards Association, the work on copper cable for transmission purposes has progressed to the point where there are offered for publication as tentative "Specifications for Hard-Drawn Copper Transmission Cable."

The committee recommends that the proposed Tentative Specifications for Hard-Drawn Copper Transmission Cable, appended hereto,[1] be accepted for publication as tentative.

The committee recommends that the Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 30) and the Standard Specifications for Bronze Trolley Wire (B 9 – 30) be revised, as given in detail below, and when so amended be continued as standard. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the revisions in these standards may be submitted to letter ballot of the Society.

Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 30):[2]

Footnote.—Change the second paragraph of footnote 1 to these specifications to read as follows by the addition of the italicized words:

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[1] See p. 666.—Ed.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 652.

These specifications were prepared jointly by the American Electric Railway Engineering Association, *the American Railway Association* and the American Society for Testing Materials.

Table I.—In Table I change the tensile strength requirement for wire 0.548 in. in diameter from "47,000" to read "46,400" lb. per sq. in. Change the area of wire 0.365 in. in diameter from "133,225 cir. mils" to read "133,200 cir. mils"; also change the area of wire 0.325 in. in diameter from "105,625 cir. mils" to read "105,600 cir. mils."

Table II.—In Table II under Section 6 (*a*) change the tensile strength requirement of wire 300,000 cir. mils in size from "44,700 lb. per sq. in." to read "44,200 lb. per sq. in."

Section 8.—Change this section to read as follows by the addition of the italicized words and figures:

> 8. For the purpose of calculating weights, cross-sections, etc., the density of the copper shall be taken as 8.89 g. per cu. cm. (*0.321 lb. per cu. in.*) at 20° C. (68° F.).

Section 11.—Change the table following Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

Nominal Area, circular mils	Actual Area, circular mils	Actual Area, sq. in.	Calculated Weight Based on Actual Area, lb. per mile
350 000	*351 200*	0.2758	5612
300 000	*299 800*	0.2355	4792
211 600	*212 000*	0.1665	3389
168 100	*167 300*	0.1314	2674
[133 225] *133 200*	*137 900*	0.1083	2205

Section 12 (b).—Change to read as follows by the addition of the italicized words:

> (*b*) Necessary brazes in trolley wire shall be *as few as possible and shall be* made in accordance with the best commercial practice.

Section 13.—Change this section to read as follows by the addition of the italicized words and figures:

> 13. All wire shall be shipped on substantial reels, suitable for the weight of the wire handled, and shall be well protected from injury. *The diameter of the reel drums shall be sufficiently large, not less than 30 in., to eliminate difficulty with waves or kinks when the wire is strung.* If reels are to be lagged, it shall be so specified by the purchaser. *The wire shall be reeled with turns tight together, in uniform layers, free from kinks and crosses. The relation between the vertical axis of grooved wire as finally strung and the axis of the reel shall be as specified by the purchaser and shall be approximately constant.*

The ends shall be securely fastened to the sides of the reel with no less than six staples. The staples shall be at least 2 in. in length and made from not less than 0.145-in. diameter wire. Care shall be exercised in stapling not to damage the surface of the exposed layer of wire. All reels shall have the arbor holes reinforced with steel plate. *Unless otherwise specified, round arbor holes shall be for a 2 $\frac{1}{2}$-in. shaft. Unless otherwise specified, shipments to railroads shall be made on reels having a 4-in. square hole reinforced with steel plate at least $\frac{1}{2}$ in. in thickness.*

Reels shall be marked legibly and indelibly with a serial number, size, kind, length, and weight of wire, and such other information as is desired by the purchaser. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

Standard Specifications for Bronze Trolley Wire (B 9 – 30):[1]

Footnote.—Change the second paragraph of footnote 1 referring to these specifications from its present form: namely,

> These specifications were prepared by Committee B-1 on Copper Wire in cooperation with a committee of the American Electric Railway Engineering Association. The specifications of the two organizations are identical.

to read as follows:

> These specifications were prepared jointly by the American Electric Railway Engineering Association, the American Railway Association and the American Society for Testing Materials.

Section 2.—In the first sentence of this section after the word "composition" add a footnote reference to refer to the following footnote:

> Where wire is to be used for steam railway electrification, the corrosive action of locomotive gases should be given consideration.

Table I.—In Table I change the tensile strength requirements for wire 0.548 in. in diameter from "66,000" to "64,800" lb. per sq. in. in the case of high-strength bronze wire; and change "59,000" to "57,800" lb. per sq. in. in the case of medium-strength bronze wire. Change the area of wire 0.365 in. in diameter from "133,225 cir. mils" to read "133,200 cir. mils"; also change the area of wire 0.325 in. in diameter from "105,625 cir. mils" to read "105,600 cir. mils."

Section 6 (a).—Omit the last sentence in this section which reads as follows: "The twist shall be omitted."

Table II.—In Table II change the tensile strength requirements for wire 350,000 cir. mils in area from "62,000" to "62,500" lb. per sq. in. in the case of high-strength bronze wire; and change "56,000" to "56,200" lb. per sq. in. in the case of medium-strength bronze

wire. Also change the tensile strength requirements for wire 300,000 cir. mils in area from "66,000" to"64,800 " lb. per sq. in. in the case of high-strength bronze wire; and change "59,000" to "57,800" lb. per sq. in. in the case of medium-strength bronze wire. Change the area of the last wire size in the table from "133,225 cir. mils" to read "133,200 cir. mils."

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 646.

New Section.—Insert a new Section 7 covering twist test to read as follows, renumbering the succeeding sections accordingly:

7. *Twist Test.*—For the purpose of determining and developing defects which may be prejudicial to the life of trolley wire, owing to its peculiar service as compared to that of wire used for other purposes, grooved bronze wire shall be subjected to the following twist test. Three twist tests shall be made upon samples 10 in. in length between the holders of the machine.

The twisting machine shall be so constructed that there is a linear motion of the tail stock with respect to the head. The twist shall be applied not faster than ten turns per minute. All three samples shall be twisted to destruction and shall not reveal under test any seams, pits, slivers, or surface imperfections of sufficient magnitude to indicate inherent defects or imperfections in the wire. At the time of fracture the wire shall be twisting with reasonable uniformity.

Wire shall not be considered satisfactory which does not stand at least three turns without breaking.

Section 8.—Renumber as Section 9 and change to read as follows by the addition of the italicized words and figures:

9. For the purpose of calculating weights, cross-sections, etc., the density of the bronze shall be taken as 8.89 g. per cu. cm. (*0.321 lb. per cu. in.*) at 20° C. (68° F.).

Section 11.—Renumber as Section 12 and change the table following Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

NOMINAL AREA, CIRCULAR MILS	ACTUAL AREA, CIRCULAR MILS	ACTUAL AREA, SQ. IN.	CALCULATED WEIGHT BASED ON ACTUAL AREA, LB. PER MILE
350 000	*351 200*	0.2758	5612
300 000	*299 800*	0.2355	4792
211 600	*212 000*	0.1665	3389
168 100	*167 300*	0.1314	2674
[133 225] *133 200*	*137 900*	0.1083	2205

Section 12 (b).—Change to read as follows by the addition of the italicized words:

(*b*) Necessary brazes in trolley wire shall be *as few as possible and shall be* made in accordance with the best commercial practice.

Section 13.—Renumber as Section 14 and change to read as follows by the addition of the italicized words and figures:

14. All wire shall be shipped on substantial reels, suitable for the weight of the wire handled, and shall be well protected from injury. *The diameter*

of the reel drums shall be sufficiently large, not less than 30 in., to eliminate difficulty with waves or kinks when the wire is strung. If reels are to be lagged, it shall be so specified by the purchaser. *The wire shall be reeled with turns tight together, in uniform layers, free from kinks and crosses. The relation between the vertical axis of grooved wire as finally strung and the axis of the reel shall be as specified by the purchaser and shall be approximately constant.*

The ends shall be securely fastened to the sides of the reel with no less than six staples. The staples shall be at least 2 in. in length and made from not less than 0.145-in. diameter wire. Care shall be exercised in stapling not to damage the surface of the exposed layer of wire. All reels shall have the arbor holes reinforced with steel plate *at least $\frac{1}{2}$ in. in thickness, and unless otherwise specified, the arbor hole shall be a 4-in. square hole.*

Reels shall be marked legibly and indelibly with a serial number, size, kind, length and weight of wire, and such other information as is desired by the purchaser. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Tentative Specifications for Hard-Drawn Copper Transmission Cable[a]	10	3	3
II. PROPOSED REVISION OF STANDARDS			
Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 30), immediate adoption	13	0	3
Standard Specifications for Bronze Trolley Wire (B 9 – 30), immediate adoption	13	0	3

[a] The classified vote on the Tentative Specifications for Hard-Drawn Copper Transmission Cable was as follows: Affirmative: 5 producers, 4 consumers, 1 general interest; negative: 3 producers, 0 consumers, 0 general interest; not voting: 0 producers, 3 consumers, 0 general interest.

The committee has held an election of officers for the ensuing two-year term which resulted in the reelection of Mr. J. A. Capp as chairman and in the selection of Mr. W. H. Bassett as vice-chairman.

This report has been submitted to letter ballot of the committee which consists of 17 members; 16 members returned their ballots, of whom 15 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

EDITORIAL NOTE

The proposed Tentative Specifications for Hard-Drawn Copper Transmission Cable were accepted for publication as tentative and appear on page 666.

The proposed immediate revisions of the Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire and for Bronze Trolley Wire were approved at the annual meeting by a unanimous vote and subsequently adopted by letter ballot of the Society on September 1, 1932. The standards in their revised form appear in the 1932 Supplement to Book of A.S.T.M. Standards, pages 9 and 14, respectively.

REPORT OF COMMITTEE B-2 ON NON-FERROUS METALS AND ALLOYS

Subcommittee I on Pure Metals in Ingot Form (W. H. Bassett, chairman).—At a meeting held in Chicago, Ill., in June, 1931, changes in the Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 28 T)[1] were approved by Subcommittee I. These revisions will be presented to Committee B-2 at a meeting to be held during this annual meeting, and if subsequently approved by letter ballot of the committee, the revisions will be submitted to the Society through Committee E-10 on Standards.[2] It is intended that the specifications, when revised, will be continued as tentative. The revisions under consideration are as follows:

Section 1.—It is proposed to change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of the words in brackets:

> (*b*) Fire-refined copper, other than Lake, is intended for use in rolling into sheets and shapes for mechanical purposes [and for certain grades of wrought-copper alloys] and is not intended for electrical purposes *nor wrought alloys.*

Section 2.—It is proposed to change the table of chemical composition following this section to read as follows by the addition of the italicized figures and the omission of the words and figures in brackets:

Copper plus silver, minimum..........	[99.7500] *99.7000* per cent
Arsenic, maximum....................	0.1000 per cent
Antimony, maximum...................	[0.0060] *0.0120* per cent
Bismuth, maximum....................	[0.0002] *0.0020* per cent
Iron, maximum.......................	[0.0050] *0.0100* per cent
Lead, maximum.......................	[0.0075] *0.0100* per cent
Nickel, maximum.....................	0.1000 per cent
Oxygen, maximum.....................	0.0750 per cent
Selenium, maximum...................	[0.0100] *0.0400* per cent
[Sulfur, maximum	0.0075] per cent
Tellurium, maximum	[0.0010] *0.0140* per cent
Tin, maximum........................	0.0500 per cent

Subcommittee I has also approved a proposed revision of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 18)[3] to include special high-grade zinc usually known as 99.99 per cent, suitable for certain die casting and other uses. The suggestion that specifications for this material be prepared was brought to the attention of Subcommittee I by Mr. H. A. Anderson, chairman of Committee B-6 on Die-Cast Metals and Alloys. The proposed revision of the standard specifications to include this additional grade will be presented to Committee B-2 at a meeting to be held during the annual meeting, and if approved by letter ballot of the committee, will be published as information until 1933 at which time the revisions will be presented to the Society for reference to letter ballot for immediate adoption as standard. The requirements for the special high-grade zinc under consideration for incorporation in Section 4 of the present Standard Specifications B 6 are as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 763 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 125.

[2] These revisions were accepted for publication as tentative and the revised specifications appear on p. 663. See Editorial Note p. 200.—Ed.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

(*1a*) *Special High Grade.*—The slab zinc (spelter) shall not contain over:
0.010 per cent lead.
0.005 per cent iron.
0.005 per cent cadmium.
It shall be free from aluminum.
The sum of the lead, iron and cadmium shall not exceed 0.010 per cent.

The subcommittee has under consideration the development of specifications for tin.

Subcommittee IV on White Metals—Tin, Lead and Zinc (G. H. Clamer, chairman).--At a meeting held in Cleveland, Ohio, in March, a subgroup was organized to draft specifications for the various type metals, namely, electrotype, linotype, monotype, stereotype, and individual type.

Revision of the Standard Specifications for White Metal Bearing Alloys (known commercially as "Babbitt Metal") (B 23 - 26) has been discussed. In this connection an account of the latest researches at the U. S. Bureau of Standards (undertaken at the suggestion of the War Department) is given in a paper[1] being presented at this annual meeting. This includes not only laboratory studies but data on the operation of bearings in service in army trucks.

Subcommittee VII on Methods of Chemical Analysis (H. V. Churchill, chairman).—In addition to the continuing investigations noted in former reports, the subcommittee is engaged in working out acceptable methods for those elements in the Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 - 28 T), mentioned above, which are not covered by existing A.S.T.M. methods.

The subcommittee has voted unaminously to recommend the advancement to standard of the current tentative revision[2] of the

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[1] H. K. Herschman and J. L. Basil, "Mechanical Properties of White-Metal Bearing Alloys at Different Temperatures," *Proceeedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 536 (1932.)

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1052 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 918.

Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19).[1] Since this recommendation has not been submitted to Committee B-2, and in view of the desire of the Society to effect economy in publication this year, it would seem better to defer the advancement of this revision as standard until 1933 when the next edition of the Book of Standards will be issued.

The subcommittee is not yet prepared to recommend the advancement to standard of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 28 T). The subcommittee feels that there are inaccuracies in these methods and in light of the fact that neither the major producer or other vendors were willing to vote affirmatively it was decided to hold these methods as tentative for one more year, during which time it is hoped that revisions can be made which will put these methods in satisfactory condition.

Subcommittee IX on Nomenclature of Metals and Alloys (E. E. Thum, chairman).—Diverse opinions have been secured from a number of men in the metal industries on the proper meaning of such terms as "Secondary Metal," "Scrap Metal," "Own Scrap," and circulated to the members of the subcommittee for consideration in an effort to formulate acceptable definitions. Several criticisms of existing definitions appearing in the Glossary of Terms prepared by Committee E-8 on Nomenclature and Definitions have been forwarded to Committee E-8.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 101 members; 84 members returned their ballots of whom 79 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

E. E. THUM,
Secretary.

EDITORIAL NOTE

The proposed revision of the Tentative Specifications for Fire-Refined Copper Other than Lake, referred to in the report, was subsequently accepted on August 11, 1932, by Committee E-10 on Standards. The specifications in their revised form appear on page 663.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 813.

REPORT OF COMMITTEE B-3

ON

CORROSION OF NON-FERROUS METALS AND ALLOYS

Since submitting its last report, Committee B-3 has been busy along many lines as will be indicated below.

The 1924 report of the Committee[1] described in some detail the practice to be followed in the preparation of specimens for and in the carrying out of laboratory accelerated corrosion tests by total immersion, continuous alternate immersion, interrupted alternate immersion, spray and accelerated electrolytic methods.

All of the above procedures were modified to some extent in the 1925 report.[1] Some methods of cleaning specimens before testing were described in the 1926 report.[1]

The results of a rather extensive program of testing of many metals in numerous different laboratories were given in the 1927 report[1] and based upon a study of these reports certain further modifications of each of these procedures were outlined. This 1927 report also contained certain critical reviews of each of these kinds of tests.

The results of further studies of the spray test were included in the 1928 report[1] and of the alternate immersion test in the 1929 report.[1]

During the past year or two, several other agencies, among them the Society's Committee A-5 on Corrosion of Iron and Steel, have undertaken sizable programs of laboratory accelerated corrosion testing. There seems to be a need for a detailed description of a recommended practice for the carrying out of each of these laboratory tests. In view of the fact that the results of these tests are not always all that would be desired, it seems fitting and proper that a critical discussion of the test should accompany its description. Some outlines and critical reviews have been prepared by various members of Committee B-3 and are incorporated herewith.

It is felt that certain general comments are in order. Descriptions of laboratory accelerated tests make it appear a little too certain that by the exercise of some care a particular type of test can be conducted under conditions which permit interpretation in terms of actual service. General experience teaches that it is very difficult so to establish and control the conditions of test that a parallelism exists with a particular type of service. Producers are trying to make materials which will stand up in service rather than in laboratory tests. Too many people try to find out what will make a good condenser tube, for example, by hanging samples from a dock, or what will make a good roofing material by immersing samples in an acid solution in a laboratory beaker.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 281 (1924); Vol. 25, Part I, p. 150 (1925); Vol. 26, Part I, p. 194 (1926); Vol. 27, Part I, p. 281 (1927); Vol. 28, Part I, p. 223 (1928); Vol. 29, Part I, p. 242 (1929).

THE PREPARATION OF SPECIMENS FOR LABORATORY ACCELERATED CORROSION TESTS[1]

Specimens of copper, nickel, aluminum, and zinc-base alloys should be prepared as follows:

Rub with No. 0 Hubert (French) emery paper followed by No. 00 Hubert (French) emery paper. The emery papers for use on aluminum specimens may be prepared by treatment with a solution of paraffin and kerosine. The scratches made by the No. 0 emery paper should be in such a direction that they will be in a vertical position when the specimen is hung in the corroding medium. Scratches made by the No. 00 paper should make an angle of 90 deg. with those made by the No. 0 paper. The emery paper may be held on a wooden polishing block covered with felt. A new piece of No. 00 paper should be used for each specimen. Pressure during rubbing should be so light as to cause no surface flow, and the resultant finish should show no evidence of a glossy polish. The rubbing should be followed by immersion in alcohol, rubbing the surface lightly with a cotton swab, rinsing in ether in order to remove all grease, finger prints, etc. Specimens should be prepared immediately before the test is started or within 24 hours of that time and preserved in a desiccator until the actual starting of the test.

Specimens of lead should not be prepared by rubbing with emery, as it is practically impossible to perform this operation without causing surface deformation or flow of the lead. Specimens shall be prepared by a removal of grease and a removal of oxide film as follows:

Rub the surface of the lead lightly with cotton soaked in ether. Immerse pieces in 40-per-cent acetic acid at ordinary temperature, allow to remain until the surface is bright, remove and rinse in slightly warm water and dry by rinsing first in alcohol and then in ether. (If the pieces of metal are dried with alcohol and ether at ordinary room temperature, the evaporation of the ether will cool them below room temperature and moisture will tend to condense on them, resulting in a tarnished surface. The purpose of the warm water is to keep the metal sufficiently above room temperature so that this will not occur.) If after the water wash and alcohol rinse a final rinse in carbon tetrachloride is used followed by drying in warm air, very little tendency to tarnish is noted. Specimens should be prepared immediately before the test is started or within 24 hours of that time and preserved in a desiccator until the actual starting of the test.

Specimens of copper and admiralty metal are best cleaned for weighing by washing with water, rubbing off all removable scale with a soft cloth, then dipping for 30 seconds in dilute sulfuric acid (10 per cent by weight) at room temperature, then rinsing in water and again rubbing with a soft cloth and finally dipping successively in warm water, alcohol and ether and allowing to dry at room temperature.

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[1] Prepared by T. S. Fuller, Metallurgist, Research Laboratory, General Electric Co.

Nickel specimens are best cleaned by a dip in 2.5-per-cent sulfuric acid solution at room temperature until bright, followed by a thorough wash in water and alcohol.

THE TOTAL-IMMERSION TEST[1]

The total-immersion test is widely used to determine the relative resistance to corrosion of various types of metals and alloys to corroding solutions. It is the simplest method available, requiring little equipment, and is quick and inexpensive. It is only representative of conditions when due regard is paid to the several factors that may influence the results obtained. The apparent simplicity of the test is deceptive, causing the inexperienced to overlook several important variables which must be controlled to obtain reproducible results. This was brought out quite clearly by a lack of agreement in test results obtained by cooperating laboratories in total-immersion tests of the same metals and alloys carried out in 1926.[2] The test results of any one laboratory were in fair agreement, but there was lack of agreement between the test data reported by the several cooperating laboratories.

The following factors must be controlled in any total-immersion test to obtain reproducible results:

Concentration of solution,
Temperature of solution,
Degree of motion of solution,
Duration of test,
Degree and method of aeration of solution,
Cleaning of specimen before and after test,
Ratio of size of specimen to volume of solution.

The concentration of a corroding solution will change during a test but this will be negligible provided a sufficient volume of solution is used relative to the total area of test material in the solution.

Corrosion rate may vary considerably with temperature. It is essential, therefore, that the temperature during the test be maintained constant.

Motion is of importance under some conditions by its indirect action on aeration and possible disturbance of formation of the protective film or the removal of loosely adherent films.

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[1] Prepared by J. R. Freeman, Jr., Technical Department, American Brass Co.

[2] *Loc. cit.*

Corrosion rate, particularly of corrosion-resistant materials, may vary considerably with time, being rapid at first but decreasing in intensity as the protective films develop. The duration of test should be over a sufficiently long period of time to permit development of the protective film. Comparisons of relative corrosion rate should be made for equal exposure periods.

The degree and method of aeration of corroding solutions is of very great importance due to the fact that under many conditions a metal or alloy is not attacked in the absence of air but may be severely attacked in the presence of air. The committee recommends, where tests under aerated conditions are to be made, the method devised by R. J. McKay published in *Industrial and Engineering Chemistry*, Vol. 15, No. 11, pp. 1114–1118.

Uniform practice should be used in cleaning the specimens before and after test. This is of particular importance in tests where weight loss is used as the measuring unit of corrosive attack. The thoroughness with which tightly adhering corrosion product is removed is in direct ratio to the loss in weight obtained.

The rate of corrosive attack is usually determined by measuring for a known period of exposure:

Loss in weight per unit area of exposed surface,
Depth and character of pitting,
Loss in tensile strength,
Loss in ductility.

The simplest method is to determine loss in weight per unit of area, since inexpensive test specimens of simple shape may be used. It is preferable to use moderately light gage sheet or strip.

Depth of pitting may be determined by direct measurement with suitable micrometers or depth gages. The maximum and average depth of pitting should be noted.

The determination of loss in tensile strength and ductility resulting from corrosion requires the preparation of tension test specimens and carrying out of tension tests both before and after exposure to corrosion. It is consequently a more expensive method of test but is necessary in certain types of materials where the corrosion attack is selective such as where intercrystalline attack occurs causing change in physical properties, in particular ductility, without marked loss in weight.

THE TOTAL-IMMERSION TEST PROCEDURE[1]

The procedure followed in the carrying out of total-immersion tests by and for the committee was first described by the committee in its report presented in 1924.[1] This was modified somewhat in later reports so that it seems worth while to summarize the procedure as last revised in 1927.

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[1] Prepared by Sam Tour, Vice-President, Lucius Pitkin, Inc.

A minimum of 250 ml. of corroding solution should be used per test specimen, and in any event sufficient to cover completely the specimen or test piece. The surfaces of the test specimens should be prepared as previously described but need not be ground flat. Cleaning of specimens should be done chemically wherever possible. Tests should be run in triplicate. Test pieces of different metals should not be placed in the same container but two or more pieces of the same metal may be in the same container if they are not in contact. Tests are run at temperatures of 30° C. ± 1° C. or at 60° C. ± 1° C., preferably maintaining temperatures by immersing the solution container in a thermostatically controlled water bath.

Solution containers may be flasks, beakers, jars or wide mouth bottles. Specimens should be hung in the solution from glass hooks or otherwise supported so that the sides are substantially vertical and so that any non-adherent corrosion product will fall away from the specimen. Metallic or corrodible material should not be used for supports.

In non-aerated tests the corroding solution should substantially fill the container and the container should be covered or stoppered with a cover or stopper. The specimens should be placed in the solution and should not be disturbed in any manner until the end of the test to avoid agitation and aeration.

In aerated tests, the air should be purified by being passed through a filter to remove any entrained oil or solid matter, then through a soda-lime tower followed by two wash bottles containing CO_2-free distilled water. The air should be introduced into the solution through a porous alundum thimble as described by R. J. McKay in *Industrial and Engineering Chemistry*, Vol. 15, No. 11, pp. 1114–1118.

The duration of the test is dependent upon the material and the corroding medium and may be hours or days. For aerated tests, evaporation losses with non-volatile solutes are made up with distilled water daily and with volatile solutes the solution is renewed daily. In the case of non-aerated tests of long duration it may be necessary to make similar renewals at stated intervals.

At the end of the exposure the specimens are removed, appearance noted, the corrosion products removed, the specimens weighed to determine loss in weight and then put to such other tests as desired.

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[1] *Loc. cit.*

In case tension test specimens are being used, they should be of recommended A.S.T.M. design for the material and should be pulled in accordance with standard A.S.T.M. procedure.[1] Loss in strength, etc., is determined by comparison with specimens not corroded.

The interpretation into service of total-immersion test results, as with all other types of corrosion tests, must be done with due regard to its limitations and representation of the service conditions under consideration. The total-immersion test cannot qualify as a standard test until satisfactory methods are devised for proper control of all variables encountered in the test method.

THE ALTERNATE-IMMERSION TEST[2]

The alternate-immersion test consists essentially of dipping the specimen in and out of the solution at a definite rate. The apparatus adopted by the committee is based on the one developed by the U. S. Bureau of Standards. In applying results obtained from the alternate-immersion test, one must consider the similarity of the test with service conditions. Such results should only be applied when service conditions are of the general nature of the alternate-immersion test. When there is a high velocity in the service conditions, results from alternate-immersion tests would probably not apply as the specimens enter and leave the solution at an extremely low velocity.

Several laboratories completed the first series of tests which are reported as part of the 1927 report of Committee B-3.[3] A study of the results shows a wide variation in the results reported by the various laboratories. In most cases the ratio of the maximum to minimum corrosion rate was greatly in excess of the 1.5 to 1 ratio thought necessary before the test may be recommended as a standard method of procedure. It is believed that certain modifications may be introduced into the test to bring about more concordant results between the various laboratories using this test.

Some of the laboratories participating in the first series of tests did not adhere to the directions laid out calling for temperature control. This would undoubtedly account for some of the discrepancies found in the results. An accurate control of temperature is highly essential. It is perhaps not so important just what this temperature is so long as it is recorded and controlled.

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[1] Tentative Methods of Tension Testing of Metallic Materials (E 8 – 27 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

[2] Prepared by D. K. Crampton, Metallurgist, Chase Brass and Copper Co., Inc.

[3] *Loc. cit.*

A longer time of test than that of the first series is necessary in order to give metal losses large enough to give reliable results. With the more resistant metals, the weight loss has been less than the experimental errors. With any metal-solution combination which would be considered commercially practicable, a time of test of 60 days or more is considered essential.

Control of the rate of drying of the samples after leaving the solution is very important. In the past series, there was no control of this feature and the temperature and humidity of the air over the apparatus gave rise to great variations. It is felt that it is highly essential that the samples either be promptly and thoroughly dried, or kept continuously wet. There are, possibly, advantages for both methods, but the indeterminate condition of uncontrolled drying should be avoided. The second series of tests by the committee is to be conducted at 60° C. in an effort to obtain almost immediate and complete drying. It is now thought that the better way is to hood the apparatus, thereby obtaining a highly humid atmosphere that will prevent the drying of the specimens. Sufficient aeration should be obtained as the space within the hood is large and the doors are opened at least twice daily for inspection, thereby replenishing the oxygen supply.

Changes in the solution due to volatility of the solute, evaporation of the solvent or chemical change should be avoided in so far as possible.

It is felt that there are advantages in running at one cycle per minute instead of the original $\frac{1}{3}$ cycle per minute. The increase in speed tends to increase the rate of attack without introducing any disadvantages.

As the test was originally outlined, the specimens were in the form of small rectangular pieces upon which loss of weight and depth of pitting was measured. One laboratory is using tension test specimens and studying losses in tensile strength and elongation. Examination of the broken specimen readily reveals structural changes such as dezincification. It is believed that there are many advantages in using the tension test specimen. It is impossible to compare results on tension test specimens of different gages. The results vary approximately inversely as the gage. It is, therefore, important to select a standard gage.

The tension test specimens should conform to the A.S.T.M. standards for sheet metal[1] and be run in triplicate. They should be suspended on edge with the long axis horizontal.

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[1] Tentative Methods of Tension Testing of Metallic Materials (E 8 – 27 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

Apparatus:

The apparatus consists of any convenient arrangement which will allow of suspending test specimens by cords in such a manner as to produce an up-and-down motion at predetermined intervals. For alternate immersion and exposure to atmosphere of equal time periods, a crank operated by a motor through a reducing gear suffices. The samples are suspended from cords extending from the crank over glass rods in such a manner that as the crank revolves, the samples are raised and lowered, producing alternate immersion. The test specimens are attached to the cords by means of glass hooks, passed through holes in the shoulders of the specimens, near the ends, in such a way that the test specimens are suspended on edge with the long axis horizontal. The diameter of the crank stroke is 4 in. and the crank makes one revolution in one minute.

The solution container is a jar or glass resistant to thermal shock, and of dimensions suitable for use with tension test specimens suspended horizontally.

The apparatus is equipped with a thermostat to maintain the temperature of solutions within ± 1° C. and is hooded so as to maintain a highly humid atmosphere above the solutions.

Procedure:

The specimens, after proper preparation, are placed in the apparatus so that they hang horizontal and are at 1 in. from the bottom of the container when at the lowest point of the cycle. The crank is revolved until the tops of the specimens are at the midpoint of the path of travel. The containers are filled with solution until the specimens are just covered. The duration of the test is 100 days and the temperature 60° C. ± 1° C.

The apparatus is opened daily and stopped at the same point as used for filling containers. Evaporation losses with non-volatile solutes are made up with additions of distilled water. Solutions are renewed every 10 days except for volatile solutes, and then daily.

At the end of the run, the specimens are removed, their appearance noted and the corrosion products removed. The specimens are weighed to determine loss in weight and then pulled in tension by the recommended A.S.T.M. procedure.[1] Loss in tensile strength and elongation is determined by comparison with specimens not corroded.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

THE SPRAY TEST[1]

The spray test apparatus as described in Bureau of Standards *Circular No. 80* on "Protective Metallic Coatings for the Rust Proofing of Iron and Steel" has become rather widely known as "The Salt Spray Test," and is often used in attempts to determine the relative corrosion resistance of materials subjected to atmospheric attack. The claim is made by some that inasmuch as chlorides are universally present in atmospheric corrosion products there is reason for using them as a base for solutions intended for accelerating corrosion. Committee B-3 investigated the adaptability of this apparatus with salt and with other than salt solutions for use in testing homogeneous materials (not metallic coatings). The results of these tests were given in the 1927 report of the committee.[2] Lack of agreement between results obtain by different laboratories was no greater in this case than in the case of some of the other types of tests. Results using salt solution showed the same great lack of agreement shown by results using other than salt solutions. The lack of agreement between two laboratories and the degree of reproducibility of results in one laboratory seem to be about the same whether sodium chloride, sodium hydroxide, hydrochloric acid, ammonia or acetic acid was used. In general, then it might be said that factors in the test which affect the results of salt spray testing also affect the results when solutions other than salt are used.

The committee is not in a position to say that the spray test method or a salt spray test should be used to test and rate metals as to their relative resistance to atmospheric corrosion. The salt spray test, however, is used rather widely in industry and, therefore, a critical discussion of it seems worth while.

THE SALT SPRAY TEST[3]

The salt spray test was originally used to determine the continuity and durability of coatings on metals. Much work has been done and some progress made toward using the test as a qualitative measurement of the corrosion resistance of materials. However, there was no set method of conducting the test and although the results obtained in individual laboratories were in general applicable to the particular material tested in terms of relative corrosion resistance, there was substantial disagreement in the results obtained by different investigators. Much of this disagreement was caused by non-uniformity in methods of conducting the test and by the use of widely varying methods of evaluating the effect of the corroding medium.

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[1] Prepared by Sam Tour, Vice-President, Lucius Pitkin, Inc.

[2] *Loc cit.*

[3] Prepared by F. P. Somers, Aluminum Research Laboratories, Aluminum Co. of America.

In view of the recognized usefulness of the test an investigation was carried out by Subcommittee III, having as its object the "specification description" of standard practices for conducting corrosion resistance tests. As a part of this investigation six different metals were tested in five different laboratories in the salt spray apparatus and the results were included in the report of the Committee for 1926.[1] The terms in which the results were reported, namely, penetration in centimeters per month and loss in weight in milligrams per square centimeter per day, were calculated to give an exact measure of the variation in results which could be expected from tests conducted under conditions common to all investigators. Unfortunately it was not possible for the individual investigators to modify their apparatus to suit the proposed conditions and the results reflected the variations in apparatus and procedure.

The conclusion drawn from the results was that under the conditions which prevailed during the investigation, the test offered little promise as a general means for determining the corrosion resistance of metals. Nevertheless, the test has been retained by investigators and its use has been extended so that it is commonly included in specifications for materials that are subjected to atmospheric corrosion. The reason for the increased use of the test is that it makes possible the rapid reproduction of the type and severity of the normal atmospheric attack on a metal and thereby furnishes a criterion of the comparative corrosion resistance of similar metals and within rather wide limits, of metals of different composition having similar characteristics.

The evaluation of results obtained in a salt spray corrosion test is probably the most important part of the test. This evaluation should be based upon changes in properties which affect the usefulness of the material. The loss in weight of a material seldom determines its life. The maximum rate of penetration of corrosion is undoubtedly the controlling factor in certain applications, but its exact measurement is difficult if not impracticable and bears no fixed relation to the average rate of penetration, which is determined by loss in weight. However, the point of weakest cross-section which approximates the point of maximum penetration of corrosion can be located and the effect of corrosion at this point measured by means of tension tests.

The mechanical properties of a material generally determine its fitness for use and the changes in these properties determine its life in service. Therefore it follows that if the loss in properties resulting from corrosion over a period of time is determined, an exact measure of the useful life of a material when subjected to any specific corroding medium can be obtained. The particular property or properties which are used for this determination depend entirely on the characteristics of the material and the use for which it is intended, but in general changes in tensile strength and elongation will furnish sufficient information for most calculations. The major advantages of this method of evaluating corrosion resistance are that it gives a result interpretable in actual service life and this result is obtained on a machine in the operation of which there is little or no personal equation involved.

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[1] *Loc. cit.*

The mechanical properties of a material are determined by testing specimens machined to arbitrary dimensions, therefore specimens of the same shape should be used for determining corrosion resistance. The dimensions of the specimen should be the same for all materials being compared and in order to obtain comparable results at least three specimens should be tested for each period of exposure. The periods of exposure should be such that specimens from the first period when tested will show a relatively slight loss in properties, thus giving a measure of the initital corrosion rate of the material. At least one, and preferably two additional groups should be tested after a more considerable loss in properties, but before total destruction. Table I illustrates the loss in properties of a low-carbon annealed steel after exposure to the 20-per-cent spray for various periods of time. Each exposure group consisted of five No. 16 gage machined tension test specimens.

TABLE I.—LOSS IN PROPERTIES OF BLUE ANNEALED S.A.E. 1010 STEEL EXPOSED TO THE 20-PER-CENT SALT SPRAY.

	12 Weeks	26 Weeks	1 Year
Percentage loss in tensile strength......	2	14	25
Percentage loss in elongation.........	36	46	54

If the loss in tensile strength is plotted against the time of exposure, it will be seen that the initial rate of corrosion of the material is slow but that after 12 weeks it rises rapidly. Tests on material exposed to the atmosphere in various localities check this rate of corrosion, although we find in this case that the length of time necessary to obtain a specific loss in tensile strength varies considerably with the location of the exposed specimen. For this reason any forecast of the absolute life of a material in a specific atmosphere based on salt spray tests is valueless. However, a comparative life can be predicted from the results of the salt spray test on two or more materials varying only slightly in composition, characteristics or fabrication history.

Table II is included to show the effect of exposure to various climatic conditions on the properties of the same material tested in the salt spray and reported above in Table I. Results are the average of five machined tensile specimens of No. 16-gage sheet taken across the grain.

The apparatus for making the salt spray test has not been standardized except for the box which in a measure has been adapted from that described in a paper by Rawdon, Krynitsky and Finkeldey presented before this Society.[1] This type, varying in some degree as to dimensions, is satisfactory for a unit size but can be made larger provided the spray nozzle produces sufficient mist and distributes it uniformly throughout the box.

The nozzle should be of an inspirator type instead of the aspirator type used by most of the investigators in the tests of 1926.[2] The reason for this is to proportion the mixture of air and solution more accurately and uniformly than can be accomplished with the aspirator. For the same reason, it should be made of monel metal accurately machined to predetermined dimensions so that all nozzles will furnish the same amount of mixture at the same air pressure. The air pressure should be in the neighborhood of 30 to 50 lb., assuring finer spray, keeping the percentage variation of pressure within smaller limits, reducing the effect of varying level of the solution and insuring enough velocity to the spray to cause even distribution throughout the box. The consumption of air should be about 150 cu. ft. per liter of solution. The nozzle should be well baffled so that droplets of solution will not be carried out around the specimens.

TABLE II.—EFFECT OF ONE YEAR'S EXPOSURE TO VARIOUS CLIMATES ON THE TENSILE STRENGTH AND ELONGATION OF S.A.E. 1010 STEEL.

	Change, per cent	
Atmosphere	Tensile Strength	Elongation
Inland industrial	−12	−6
Semi-industrial	−16	+8
Atlantic coast	−53	−51
Equatorial	−2	+1

The spray or mist should be introduced beneath the specimens and allowed to rise and vent itself around the top of the box. The size of mist particle which can be carried by the air varies with its velocity and as the velocity falls off these particles and the larger droplets which tend to form will drop down. In order to prevent specimens nearer the spray from receiving more solution than those farther away, the mist should come in below the specimens. For a related reason the specimens should be exposed in as nearly a vertical position as possible. Any slant or tilt of a specimen will cause it to catch the condensed droplets on its upper side and show a greater corrosion effect on this side.

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[1] H. S. Rawdon, A. I. Krynitsky and W. H. Finkeldey, "Types of Apparatus Used in Testing the Corrodibility of Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 717 (1924).

[2] *Loc. cit.*

The tests run in 1926 used the 6-per-cent NaCl solution as the corroding medium. A sea salt solution or sea water and the 20 per cent NaCl solution have also been widely used. The use of sea salt or sea water, on account of non-uniformity of composition, is unsound practice. It affords a more rapid attack, but the same quantitative results can be obtained in the same length of time by cutting down the gage of the specimens. The strength of the 20-per-cent salt solution can be maintained within narrow limits and a larger background of experience has been built upon its use than has been built on any other concentration. The losses in properties after a definite period of exposure are comparable to those obtained with other concentrations. The specific objection to its use is the tendency of solid salt to deposit on the specimens and around the spray nozzle, but this effect in reality only indicates improper functioning of the apparatus, that is the incoming air is not saturated, the proportion of air to solution is too great or that the tube from the solution to the nozzle is stopped up. In other words, as soon as the concentration of the solution in the mist is too low this effect shows up, where with lower concentrations of salt an appreciable time might pass while the concentration of solution on the specimens was building up to the saturation point of salt before any trouble could be noted.

The amount of solution to be used per day should be of the nature of ½ liter per cubic foot of space in the box. If less than this is used the mist will be found to be on the dry side and more than this amount is a waste. The proper baffling of the nozzle by returning the coarser spray to the solution will cut down the apparent consumption. Of course no condensed solution which has circulated through the specimens can be re-used so provision must be made to drain this off before it contaminates the unused solution.

The type of corrosion, as regards microscopic character, resulting from salt spray exposure is similar to that which obtains after atmospheric exposure, although the physical character of the corrosion product may be quite different. This difference is partly the result of continuous wetting in the spray, whereas there is intermittent wetting and drying in the atmosphere. Because of this difference, the results of salt spray tests must be correlated with those from the atmospheric test on the same material before conclusions as to service life can be drawn.

The salt spray is well adapted for the control of quality of standard materials and for the investigation of the types of corrosion to which new materials may be susceptible. By the inclusion of specimens of standard materials having known corrosion losses, it is possible to eliminate errors arising from temperature changes, failure of apparatus or other operating variables. Variations in the results of the corrosion test of the standard specimens are interpreted as reflecting variations in the conduct of the test and results of tests on accompanying materials can be corrected or discounted proportionally.

ACCELERATED ELECTROLYTIC TEST

The results of the work of the committee with this test are well summarized in the 1927 report.[1] The opinion of the committee is that the results from this test do not have a direct bearing upon the corrosion rate of the metals in the various mediums used and that the results of this test cannot be expected to agree with those of other tests. This is especially true where protective film formation is an important factor.

In view of the above, the committee does not believe it advisable to devote further time or space to this test at this time.

CORROSION TESTS IN THE FIELD

There is appended to this report a report of Subcommittee VI on Atmospheric Corrosion which outlines the comprehensive tests that are now being carried out at several locations in the field. There is also appended a report of Subcommittee VII on Corrosion in Liquids which gives the program of field tests being carried out by that committee. The report of Subcommittee VIII on Galvanic and Electrolytic Corrosion is also appended, which gives a description of the galvanic couples that are being exposed at the various test locations.

MATERIALS FOR TESTS

The testing programs of Subcommittee VI, VII and VIII require a considerable quantity of special materials in various shapes and sizes as is more fully described in the separate reports of these subcommittees appended hereto. The entire work of procuring these

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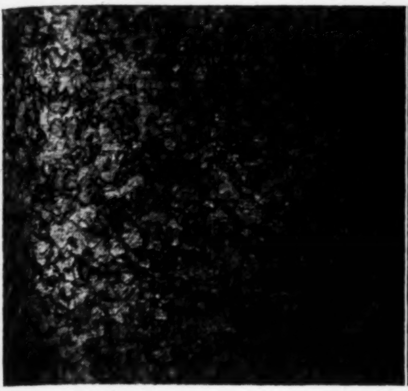
[1] *Loc. cit.*



A: COMMERCIAL COPPER, TOUGH PITCH, 0.035 IN. THICK (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	99.983	Lead	0.0012
Oxygen	0.0259	Iron	0.0014
Sulfur	0.0015	Nickel	0.0019
Silver	0.0006	Tin	0.0013
Arsenic	0.0009	Selenium	0.0005
Antimony	0.0002	Tellurium	0.0008
Bismuth..less than	0.0001		

Physical Properties:

Tensile strength, lb. per sq. in	35 210
Elongation in 2 in., per cent	42.5

A: COMMERCIAL COPPER, TOUGH PITCH, 2 BY $\frac{1}{16}$ IN. THICK (ETCHED, × 75).

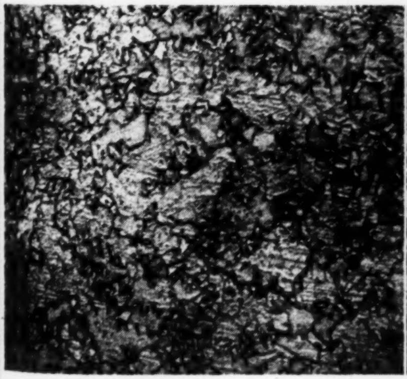
Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VIII.

Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	99.959	Lead	0.0003
Oxygen	0.0473	Iron	0.0012
Sulfur	0.0031	Nickel	0.0015
Silver	0.0008	Tin	0.0007
Arsenic	0.0011	Selenium	0.0018
Antimony	0.0004	Tellurium	0.0011
Bismuth..less than	0.0001		



A: COMMERCIAL COPPER, TOUGH PITCH, 9 BY $\frac{1}{16}$ IN. THICK (ETCHED, × 75).

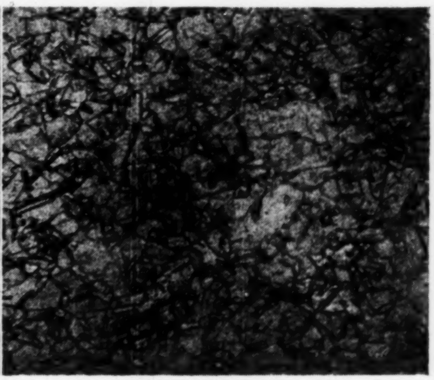
Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VIII.

Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	99.971	Lead	0.0003
Oxygen	0.0344	Iron	0.0014
Sulfur	0.0036	Nickel	0.0016
Silver	0.0008	Tin	0.0009
Arsenic	0.0013	Selenium	0.0010
Antimony	0.0004	Tellurium	0.0007
Bismuth..less than	0.0001		



B: COMMERCIAL COPPER, PHOSPHORIZED (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittees VI and VII.

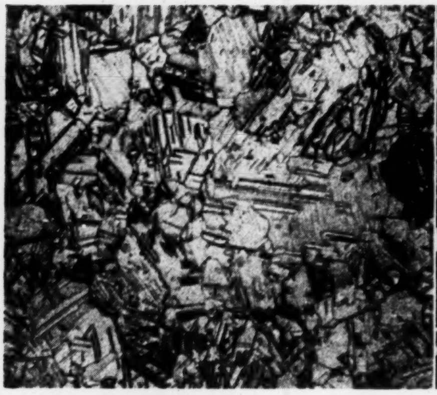
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	99.97	Bismuth	0.00001
Phosphorus	0.007	Lead	0.0023
Oxygen	0.0011	Iron	0.0046
Sulfur	0.0017	Nickel	0.0085
Silver	0.0017	Tin	0.0049
Arsenic	0.0014	Selenium	0.0006
Antimony	0.0002	Tellurium	0.0013

Physical Properties:

Tensile strength, lb. per sq. in	35 150
Elongation in 2 in., per cent	38.7



C: COPPER-SILICON-MANGANESE ALLOY (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittees VI and VII.

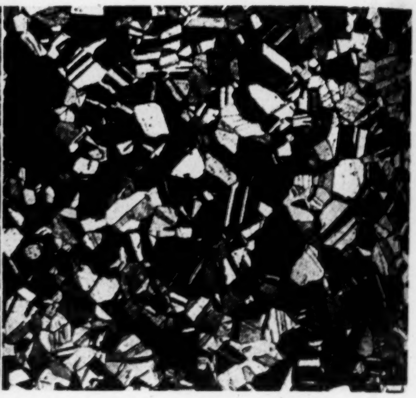
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	95.95	Silicon	2.88
Iron	0.09	Manganese	1.13

Physical Properties:

Tensile strength, lb. per sq. in	59 050
Elongation in 2 in., per cent	55.7



D: TIN BRONZE, 92 – 8 (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittees VI, VII, VIII.

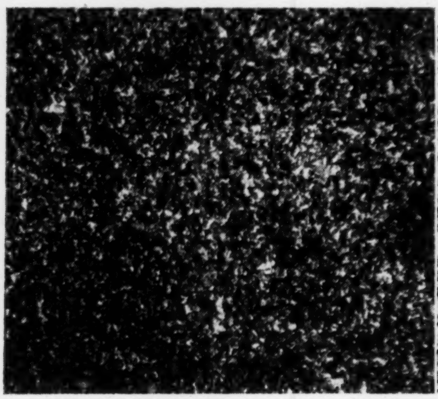
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	92.22	Phosphorus	0.03
Tin	7.85		

Physical Properties:

Tensile strength, lb. per sq. in	49 758
Elongation in 2 in., per cent	66.2



E: ALUMINUM BRONZE, COPPER 95 PER CENT, ALUMINUM 5 PER CENT (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VII.

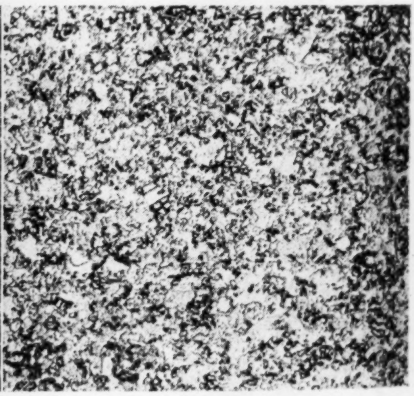
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	94.81		
Iron	0.12	Aluminum (by difference)	5.07

Physical Properties:

Tensile strength, lb. per sq. in	66 000 – 73 300 – 65 700
Elongation in 2 in., per cent	47 – 34.5 – 46.5



F: ALUMINUM BRONZE, COPPER 92 PER CENT, ALUMINUM 8 PER CENT, LOT NO. 1 (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VI (tensile specimens groups 1-F to 7-F inclusive, also 11-F, original tests on unexposed material; 9 by 12-in., specimens 1-F to 7-F); Subcommittee VII; also for laboratory tests by Subcommittees I, II, III, V.

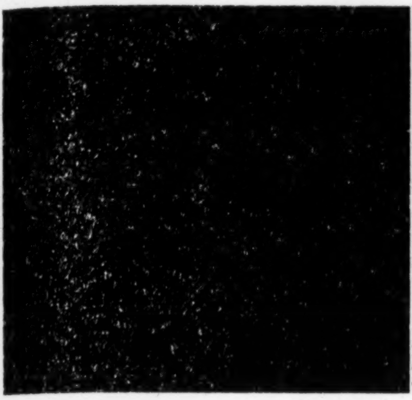
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	92.12	Aluminum (by difference)	7.76
Iron	0.12		

Physical Properties:

Tensile strength, lb. per sq. in	89 516
Elongation in 2 in., per cent	29.2



F: ALUMINUM BRONZE, COPPER 92 PER CENT, ALUMINUM 8 PER CENT, LOT NO. 2 (ETCHED, × 75).

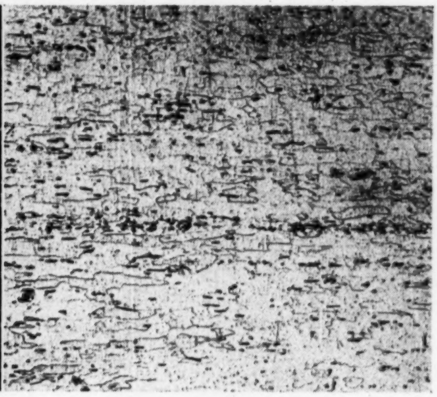
Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VI (tensile specimen groups -F to 10-F inclusive, also 11-Fa, original tests on unexposed material; 9 by 12-in. specimens 8-F and 9-F); also for "spare material."

Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	92.12	Aluminum	7.83
Iron	0.05	(by difference)	



G: COMMERCIAL ALUMINUM, 0.035 IN. THICK (ETCHED, $\frac{1}{2}$ PER CENT HF, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Hot rolled from 5 by 18 by 21-in. ingot to $\frac{3}{8}$-in-thick slab. Slab cold rolled to 0.057 in., annealed, cold rolled to 0.035 in. (cold worked 40 per cent).

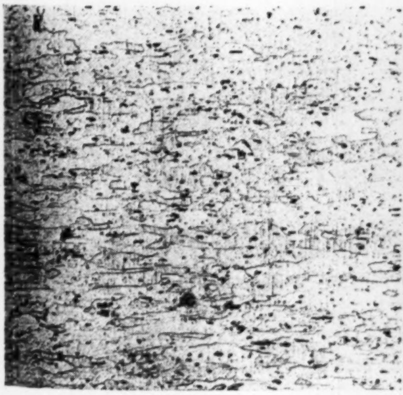
Chemical Analysis, per cent:

Silicon	0.21	Manganese	
Iron	0.64	Magnesium	
Copper	0.01	Aluminum	99.16

Physical Properties:

Tensile strength, lb. per sq. in	17 210
Yield strength, lb. per sq. in	14 350
Elongation in 2 in., per cent	11.8
Brinell hardness number	33

NOTE.—Micrographs of this material are also available at 500 magnifications showing complex combinations of aluminum, iron and silicon.



G: COMMERCIAL ALUMINUM, 0.064 IN. THICK (ETCHED, $\frac{1}{2}$ PER CENT HF, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Hot rolled from 15 by 18 by 21-in. ingot to $\frac{3}{8}$-in-thick slab. Cold rolled to 0.081 in., annealed, cold rolled to 0.064 in. (cold worked 40 per cent).

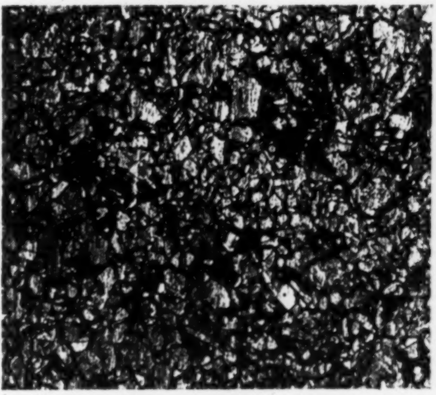
Chemical Analysis, per cent:

Silicon	0.21	Copper	0.01
Iron	0.64	Aluminum	99.16

Physical Properties:

Tensile strength, lb. per sq. in	16 670 - 16 410
Yield strength, lb. per sq. in	13 200
Elongation in 2 in., per cent	15.0 - 14.6
Brinell hardness number	35.2

NOTE.—Micrographs of this material are also available at 500 magnifications showing combinations of aluminum, iron and silicon.



H: ALUMINUM BRONZE (ETCHED, × 75).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittee VII.

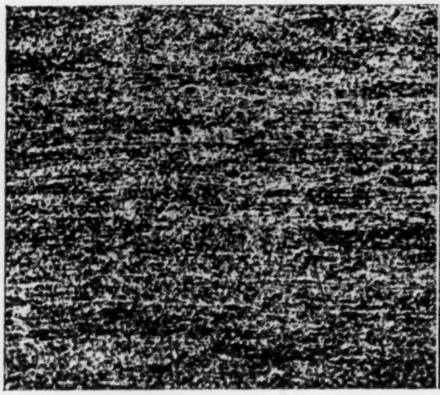
Process of Manufacture: Hot rolled and annealed.

Chemical Analysis, per cent:

Copper	89.94	Nickel	0.53
Tin	0.37	Aluminum	8.30
Iron	0.86		

Physical Properties:

Tensile Strength, lb. per sq. in.	88 600 - 90 300 - 91 700
Elongation in 2 in., per cent	15 - 20 - 22.5



I: ALUMINUM-MANGANESE ALLOY (ETCHED, $\frac{1}{2}$ PER CENT HF, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Hot rolled from $4\frac{3}{4}$ by 12 by 24-in. ingot to $\frac{3}{8}$-in-thick slab, cold rolled to 0.057 in., annealed, cold rolled to 0.035 in. (cold worked 40 per cent).

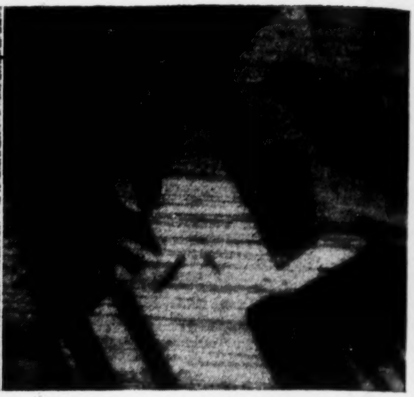
Chemical Analysis, per cent:

Silicon	0.17	Manganese	1.08
Iron	0.40	Aluminum	98.30
Copper	0.05		

Physical Properties:

Tensile strength, lb. per sq. in.	20 930 – 20 450
Yield strength, lb. per sq. in.	17 900
Elongation in 2 in., per cent	9.0 – 9.41
Brinell hardness number	37.6

NOTE.—Micrographs of this material are also available at 500 magnifications showing the constituents in greater detail.



J: LOW-CARBON NICKEL-CHROMIUM-IRON ALLOY (ETCHED, × 200).

Supplied by: The Duririon Co., Inc.

Exposure Tests by: Subcommittee VII.

Process of Manufacture: Rolled and annealed in accordance with commercial practice followed on chromium-nickel steel.

Chemical Analysis, per cent:

Nickel	22.35	Copper	0.39
Chromium	20.57	Manganese	0.68
Silicon	2.80	Total Carbon	0.04
Molybdenum	1.68	Iron	remainder

Physical Properties:

Tensile strength, lb. per sq. in.	86 000 – 84 700 – 85 100
Elongation in 2 in., per cent	45 – 40 – 31

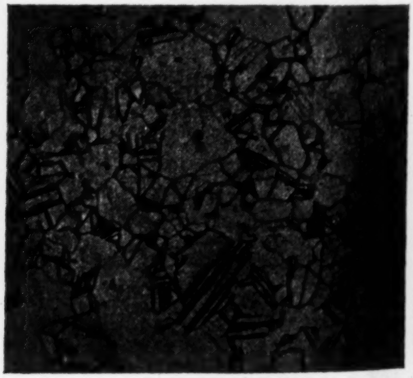
K: MANGANESE BRONZE.

Supplied by: American Manganese Bronze Co.

Exposure Tests by: Subcommittees VI and VII.

Physical Properties:

Tensile strength, lb. per sq. in.	121 998
Elongation in 2 in., per cent	8.45



L: BRASS, 85 — 15 (ETCHED, × 75).

Supplied by: Bridgeport Brass Co.

Exposure Tests by: Subcommittees VI and VII.

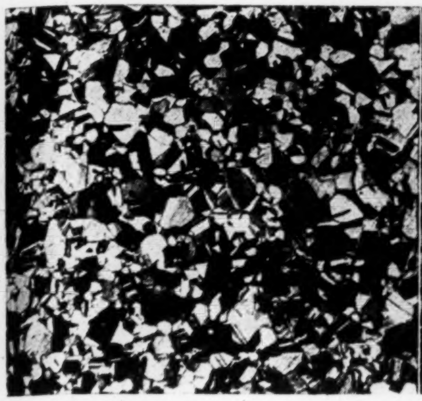
Process of Manufacture: Chill cast 8 by 3 in. in cast iron mold, broken down hot to $\frac{5}{8}$ in., overhauled, cold rolled to 0.056 in. with intermediate anneals in accordance with mill practice, mill annealed at 600° C., finished to 0.035 in., and mill annealed at 600° C.

Chemical Analysis, per cent:

Copper	85.76	Tin	none
Lead	0.015	Zinc	remainder
Iron	0.016		

Physical Properties:

Tensile strength, lb. per sq. in.	39 900
Elongation in 2 in., per cent	42.4



M: BRASS, 70 — 30 (ETCHED, × 75).

Supplied by: Chase Companies, Inc.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Due to the difference in size and type of test specimens some material was rolled from $4\frac{1}{2}$-in. bars and some from $12\frac{1}{2}$-in. bars. All the metal was cast from the same heat, so would have within commercial limits the same analysis.

The $4\frac{1}{2}$-in. metal was annealed a light anneal on 0.059 in. and rolled to 0.035 in. and finished with a light anneal. Subsequently it was pickled in ordinary sulfuric acid pickle and washed, then slit and flattened and cut up for test specimens.

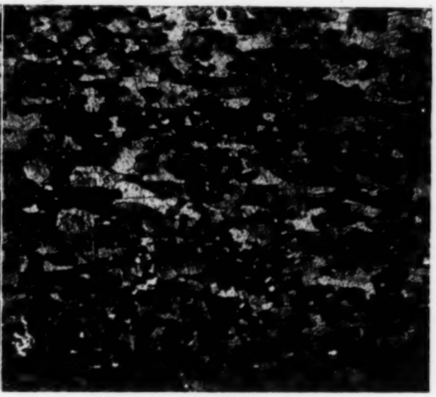
The $12\frac{1}{2}$-in. metal was treated identically the same except that it was finished rolled from 0.051 in. to 0.035 in.

Chemical Analysis, per cent:

Copper	69.65	Iron	0.003
Lead	0.027	Zinc	remainder

Physical Properties:

Tensile strength, lb. per sq. in.	48 033
Elongation in 2 in., per cent	52.3



O: DURALUMIN (ETCHED, HF, HCl, HNO_3, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittees VI, VII, VIII.

Process of Manufacture: Hot rolled from $3\frac{3}{4}$ by 12 by 24-in. ingot to $\frac{1}{4}$-in.-thick slab, annealed, cold rolled to 0.10 in. thick, annealed, cold rolled to 0.06 in. thick, annealed, finished to 0.035 in. Heated in fused sodium nitrate 15 minutes at 950° F., quenched in cold water. Sheared and flattened after heat treatment.

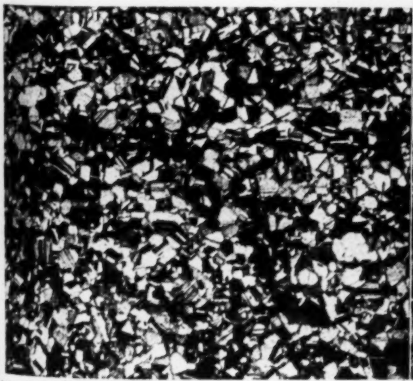
Chemical Analysis, per cent:

Silicon	0.42	Manganese	0.57
Iron	0.34	Magnesium	0.57
Copper	4.32	Aluminum	93.78

Physical Properties:

Tensile strength, lb. per sq. in.	68 720 – 63 760
Yield strength, lb. per sq. in.	34 000
Elongation in 2 in., per cent	21 – 20.7
Brinell harness number	106.2

NOTE.—Micrographs of this material at 500 magnifications are also available showing a few particles of the copper-iron-manganese complex (darkened by etching) in the aluminum solid solution matrix. The various grain orientations of the aluminum are indicated by the extent of the etching attack.



N: ADMIRALTY METAL (ETCHED, × 75).

Supplied by: Scovill Mfg. Co.

Exposure Tests by: Subcommittees VI and VII.

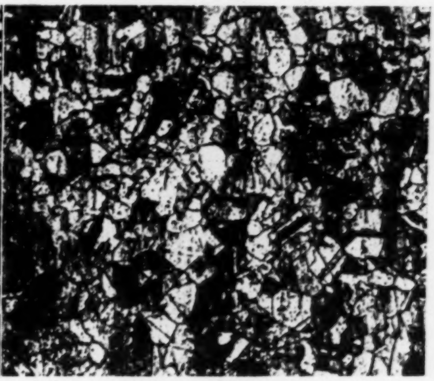
Process of Manufacture: Cold rolled from 0.075 in. to 0.035 in. and annealed for 2 hours and 20 minutes at 460° C.

Chemical Analysis, per cent:

Copper	69.75	Tin	1.22
Lead	0.01	Zinc	29.01
Iron	0.01	(by difference)	

Physical Properties:

Tensile strength, lb. per sq. in.	54 960
Elongation in 2 in., per cent	51



P: COPPER-NICKEL-ZINC ALLOY METAL (ETCHED, × 150).

Supplied by: American Brass Co.

Exposure Tests by: Subcommittees VI and VII.

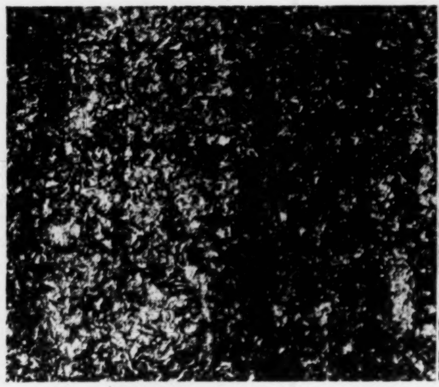
Process of Manufacture: Cold rolled and annealed.

Chemical Analysis, per cent:

Copper	74.52	Nickel	20.11
Zinc (by difference)	4.91	Manganese	0.46

Physical Properties:

Tensile strength, lb. per sq. in.	54 350
Elongation in 2 in., per cent	31.5



Q: Copper-Nickel-Tin Alloy (Etched, × 200).

Supplied by: Scovill Mfg. Co.

Exposure Tests by: Subcommittees VI and VII.

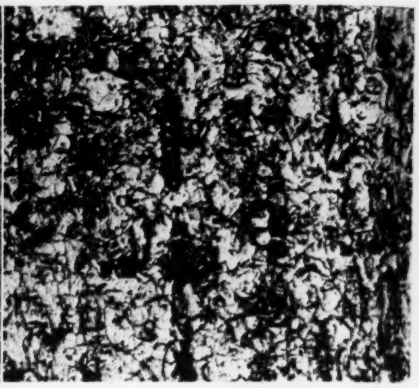
Process of Manufacture: Cold rolled from 0.064 in. to 0.035 in. and annealed for 2 hours and 20 minutes at 680° C. in a container with charcoal.

Chemical Analysis, per cent:

Copper	69.10	Manganese	0.40
Nickel	28.64	Carbon	0.075
Tin	1.04	Zinc	0.551
Iron	0.194		

Physical Properties:

Tensile strength, lb. per sq. in.	76 790
Elongation in 2 in., per cent	24.2



R: Cupro Nickel (Etched, × 200).

Supplied by: Scovill Mfg. Co.

Exposure Tests by: Subcommittees VII and VIII.

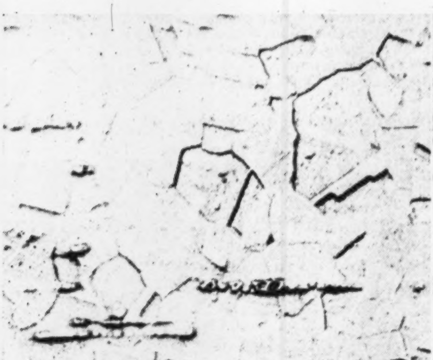
Process of Manufacture: Cold rolled from 0.064 in. to 0.035 in. and annealed for 2 hours and 20 minutes at 680° C. in a container with charcoal.

Chemical Analysis, per cent:

Copper	82.55	Tin	0.04
Lead	0.01	Nickel	17.33
Iron	0.07		

Physical Properties:

Tensile strength, lb. per sq. in.	52 000 - 51 300 - 52 100
Elongation in 2 in., per cent	30.5 - 30.5 - 30.5



S: Nickel-Copper Alloy (Etched, × 250).

Supplied by: The International Nickel Co., Inc.

Exposure Tests by: Subcommittees VI, VII, VIII.

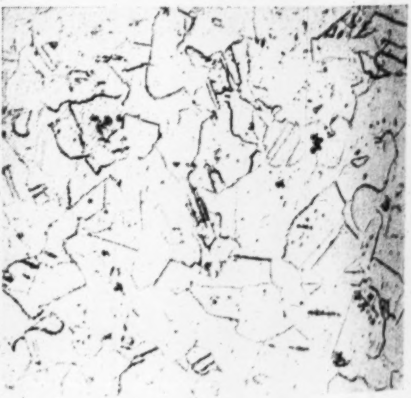
Process of Manufacture: Soft annealed in a reducing atmosphere in a continuous heating furnace after cold rolling. Final cold reduction before this final anneal of 59 per cent. All preliminary reduction was by hot rolling.

Chemical Analysis, per cent:

Iron	1.66	Manganese	0.97
Carbon	0.13	Nickel (including cobalt)	65.64
Sulfur	0.005	Copper	31.55

Physical Properties:

Tensile strength, lb. per sq. in.	79 840
Elongation in 2 in., per cent	35.65



T: Commercial Nickel (Etched, × 250).

Supplied by: The International Nickel Co., Inc.

Exposure Tests by: Subcommittees VI, VII, VIII.

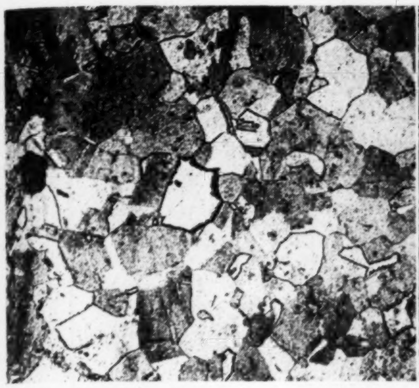
Process of Manufacture: Soft annealed in a reducing atmosphere in a continuous heating furnace after cold rolling. Final cold reductions before this final anneal of 48.5 and 71 per cent. All preliminary reduction was by hot rolling.

Chemical Analysis, per cent:

Copper	0.08	Carbon	0.09
Nickel (including cobalt).	99.30	Sulfur	0.005
		Manganese	0.14
Iron	0.31	Silicon	0.05

Physical Properties:

Tensile strength, lb. per sq. in.	71 040
Elongation in 2 in., per cent	35.8



U: CHEMICAL LEAD (ETCHED, × 75).

Supplied by: National Lead Co.

Exposure Tests by: Subcommittees VI, VII, VIII.

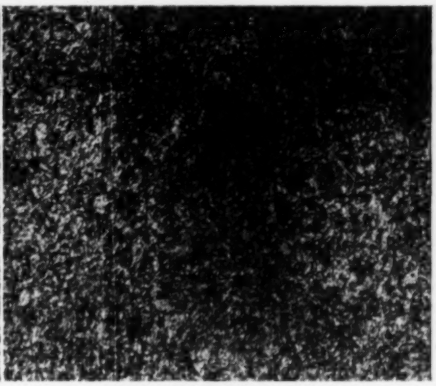
Process of Manufacture: Practically cold rolled.

Chemical Analysis, per cent:

Lead (by difference)	99.9246	Silver	0.0068
		Bismuth	0.011
Antimony	0.0010	Tin	not over 0.0001
Copper	0.0603	Arsenic	not over 0.00008
Iron	0.0002	Zinc	not over 0.0002
Nickel	0.0060	Cadmium	not over 0.0002

Physical Properties:

Tensile strength, lb. per sq. in. 2580
Elongation in 2 in., per cent 43.6



V: IRON-CHROMIUM ALLOY (ETCHED, × 100).

Supplied by: Allegheny Steel Co.

Exposure Tests by: Subcommittee VII.

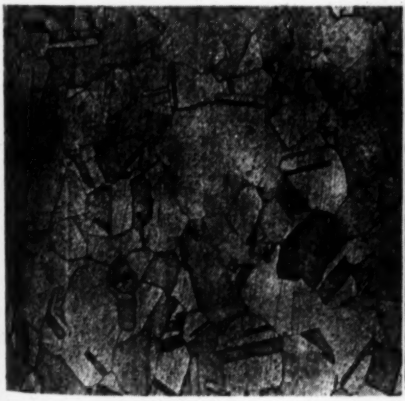
Process of Manufacture: Hot rolled, annealed in a closed box at a temperature of 1500° F., slow cooled, pickled, cold rolled (one light pass) and polished.

Chemical Analysis, per cent:

Carbon	0.12	Silicon	0.181
Manganese	0.39	Chromium	14.43
Phosphorus	0.017	Nickel	0.236
Sulfur	0.016	Iron	remainder

Physical Properties:

Tensile strength, lb. per sq. in. .... 74 600 – 64 800 – 65 500
Elongation in 2 in., per cent ...... 23 – 21 – 19



W: IRON-CHROMIUM-NICKEL ALLOY (ETCHED, × 100).

Supplied by: Allegheny Steel Co.

Exposure Tests by: Subcommittees VII and VIII.

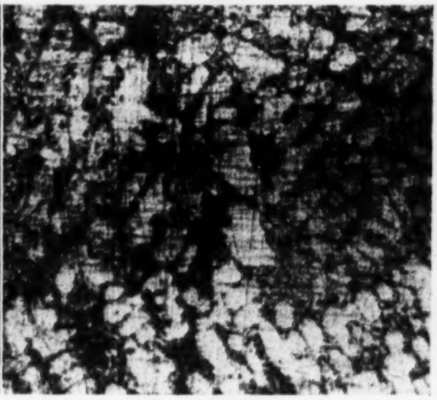
Process of Manufacture: Hot rolled, open annealed at a temperature of 1950° F., cooled rapidly, pickled, cold rolled (one light pass) and polished.

Chemical Analysis, per cent:

Carbon	0.11	Silicon	0.249
Manganese	0.38	Chromium	18.90
Phosphorus	0.020	Nickel	8.56
Sulfur	0.018	Iron	remainder

Physical Properties:

Tensile strength, lb. per sq. in.. 100 000 – 102 000 – 98 600
Elongation in 2 in., per cent... 54.5 – 59 – 52



X: SILICON CAST IRON, 0.035 IN. THICK (ETCHED, × 250).

Supplied by: The Duriron Co., Inc.

Exposure Tests by: Subcommittee VII.

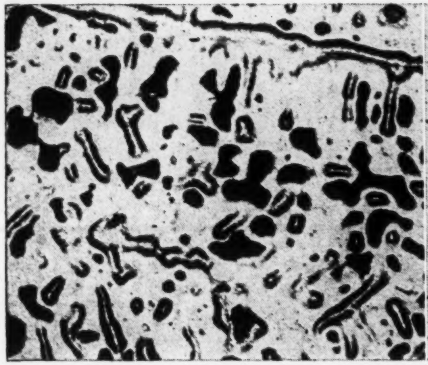
Process of Manufacture: Cast in the form of test specimens.

Chemical Analysis, per cent:

Silicon	14.61	Total carbon	0.72
Manganese	0.46	Iron	remainder

Physical Properties:

Tensile strength, lb. per sq. in. .... 18 250 – 23 920



Y: Leaded Bronze (Etched, × 150).

Supplied by: Federal Mogul Corp.

Exposure Tests by: Subcommittee VII.

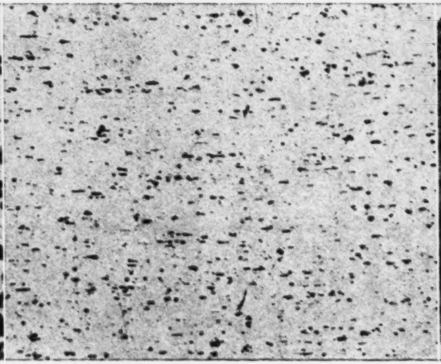
Process of Manufacture: Cast in sand.

Chemical Analysis, per cent:

Copper	75.20	Lead	14.69
Tin	9.86		

Physical Properties:

Tensile strength, lb. per sq. in.	33 650 - 34 700
Yield point, lb. per sq. in.	19 340 - 19 520
Elongation in 2 in., per cent	15.5 - 15.5
Reduction of area, per cent	22.2 - 21.8



Z: Aluminum-Magnesium-Silicon Alloy (Etched, $\frac{1}{2}$ per cent HF, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittee VI.

Process of Manufacture: Hot rolled from $3\frac{3}{4}$ by 12 by 24-in. ingot, to $\frac{1}{4}$-in.-thick slab, cold rolled to 0.10 in., annealed and cold rolled to 0.035 in. Heated for 20 minutes in fused nitrate bath at 970° F. and quenched in cold water. Sheared and flattened.

Chemical Analysis, per cent:

Silicon	0.96	Manganese	0.03
Iron	0.49	Magnesium	0.59
Copper	0.16	Aluminum	97.77

Physical Properties:

Tensile strength, lb. per sq. in.	35 340 to 37 980
Yield strength, lb. per sq. in.	25 150
Elongation in 2 in., per cent	21.5 to 23.9
Brinell harness number	72.8

Note.—Micrographs of this material are also available at 500 magnifications showing the constituents after a light etch.

AA: Commercial Zinc (Prime Western) (Eiched, × 100).

Supplied by: New Jersey Zinc Co.

Exposure Tests by: Subcommittee VI.

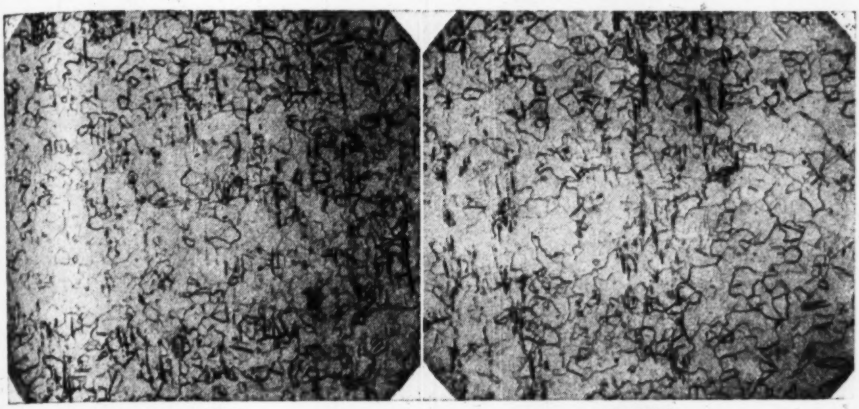
Process of Manufacture: Pack rolled from 0.088 in. to 0.035 in. according to commercial mill practice.

Chemical Analysis, per cent:

Lead	0.84	Arsenic	0.0001
Iron	0.012	Zinc	remainder
Cadmium	0.20		

Physical Properties:

Tensile strength, lb. per sq. in.	29 900
Elongation in 2 in., per cent	34.3



(*a*) 0.036 in (*b*) 0.063 in

BB: COMMERCIAL ZINC (HIGH GRADE) (ETCHED, × 100).

Supplied by: New Jersey Zinc Co.

Exposure Tests by: Subcommittees VI and VII.

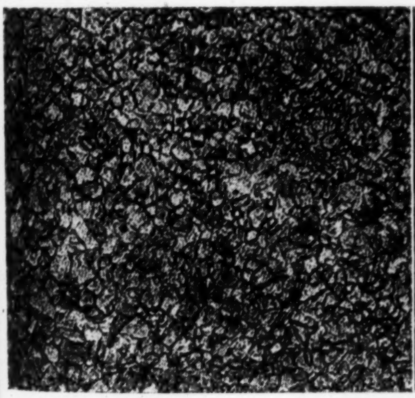
Process of Manufacture: Hot rolled according to commercial mill practice.

Chemical Analysis, per cent:

Lead	0.049	Arsenic	0.0006
Iron	0.019	Zinc	remainder

Physical Properties:

Tensile strength, lb. per sq. in.	18 280
Elongation in 2 in., per cent	58.5



CC: 1 PER CENT ANTIMONIAL LEAD (ETCHED, × 75).

Supplied by: National Lead Co.

Exposure Tests by: Subcommittee VI.

Process of Manufacture: Rolled at slightly elevated temperatures, not exceeding 100° C. The last rolling gives approximately a reduction of $\frac{1}{16}$ in. with a final pass with reduction of 0.008 in. The sheets are not annealed during or after rolling.

Chemical Analysis, per cent:

Lead (by difference)	98.795	Copper	0.070
		Arsenic	none
Tin	0.020	Nickel	0.015
Antimony	1.10		

Physical Properties:

Tensile strength, lb. per sq. in.	3480
Elongation in 2 in., per cent	45.3

EE: COMMERCIAL TIN (ETCHED, × 75).

Supplied by: National Lead Co.

Exposure Tests by: Subcommittees VI and VIII.

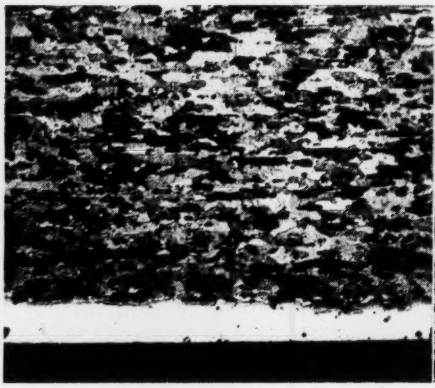
Process of Manufacture: Practically cold rolled.

Chemical Analysis, per cent:

Lead	0.040	Nickel and Cobalt	0.0072
Tin (by difference)	99.8659	Bismuth	0.0094
		Sulfur	0.0014
Antimony	0.012	Phosphorus	trace
Copper	0.0091	Cadmium	none
Arsenic	0.0457	Silver	none
Iron	0.0093	Zinc	none

Physical Properties:

Tensile strength, lb. per sq. in.	3760
Elongation in 2 in., per cent	69



FF: Aluminum-Coated Duralumin (Etched, HF, HCl, HNO_3, × 100).

Supplied by: Aluminum Company of America.

Exposure Tests by: Subcommittee VI.

Process of Manufacture: Hot rolled from 3¾ by 12 by 24-in. ingot to ¼-in.-thick slab, annealed, cold rolled to 0.10 in., annealed cold rolled to 0.06 in., annealed, finished to 0.035 in. Heated in fused sodium nitrate 15 minutes at 940° F., quenched in cold water. Sheared and flattened.

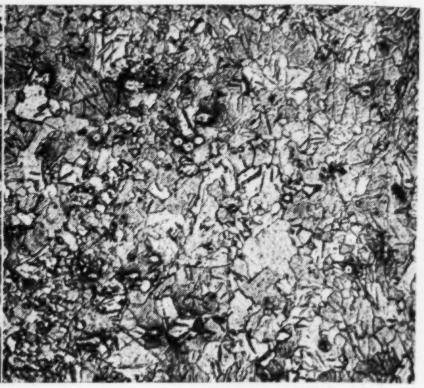
Chemical Analysis, per cent:

Silicon	0.49	Manganese	0.61
Iron	0.47	Magnesium	0.52
Copper	4.23	Aluminum	93.68

Physical Properties:

Tensile strength, lb. per sq. in.	56 180 - 58 790
Yield strength, lb. per sq. in.	28 000
Elongation in 2 in., per cent	19.5 - 19.46

Note.—Micrographs of this material are also available at 500 magnifications showing in detail the bond between the high purity coating and the strong alloy core as a true alloy. The structure consists of a few particles of the copper-iron-manganese complex in an aluminum solid solution matrix.



HH: Zinc, 99.99 + per cent (Etched, × 100).

Supplied by: St. Joseph Lead Co.

Exposure Tests by: Subcommittee VI.

Process of Manufacture: Rolled hot to about 0.05 in. thick and then rolled to a finishing thickness. There was no annealing.

Chemical Analysis, per cent:

Lead	0.0055	Iron	0.0015
Cadmium	0.0010	Aluminum	none
Copper	0.0006	Zinc (by difference)	99.9914

Physical Properties:

Tensile strength, lb. per sq. in.	19 350
Elongation in 2 in., per cent	51.6

GG: Mild Steel.

	Tensile Specimen Stock 12 by 0.035 in.	Couple Disks Stock 2 by 0.062 in.	Reserve Stock 9 by 0.062 in.
Melting process	Basic open-hearth	Basic open-hearth	Basic open-hearth
Size of billett	12 by 3 in.	2 by 2 in.	9 by 3 in.
Billett temperature	2200° F.	2200° F.	2200° F.
Finish temperature	1600° F.	1600° F.	1600° F.
Hot roll size	12 by 0.065 in.	2 by 0.109 in.	9 by 0.109
Pickled	Yes	Yes	Yes
Cold rolled to	12 by 0.035 in.	2 by 0.062 in.	9 by 0.062 in.
Box annealed at	1250° F.	1250° F.	1250° F.
Carbon, per cent	0.06	0.095	0.050
Manganese, per cent	0.38	0.41	0.36
Sulfur, per cent	0.035	0.032	0.035
Phosphorus, per cent	0.013	0.011	0.011
Yield point, lb. per sq. in.	32 800	32 200	30 200
Tensile strength, lb. per sq. in.	48 600	46 200	44 900
Elongation in 4 in., per cent	30.8	33.6	34.3
Scleroscope	17 - 18	17 - 17	17 - 18
Rockwell hardness number	49 - 50	47 - 47	43 - 44

test materials, having them machined or otherwise prepared, obtaining data regarding their method of fabrication, their analysis and properties and supplying all to the interested subcommittees has been very ably accomplished by Mr. John L. Christie acting as a subcommittee of one on materials.

In obtaining these materials, Mr. Christie not only obtained the amounts required for the immediate test programs of the subcommittees, but also additional materials to be held in reserve for future purposes. These reserve materials are being stored at the Bureau of Standards in Washington, D. C. Information regarding the materials is presented in connection with the accompanying photomicrographs showing the structure of the materials. It will be noted that each material has been given an identification letter.

MISCELLANEOUS ITEMS

The extensive corrosion test programs described in the several subcommittee reports do not contemplate laboratory studies of tarnish or corrosion films as a committee activity. Arrangements have been made, however, so that the Bureau of Standards will carry out studies of the films formed on the metals subjected to atmospheric corrosion. The tension test specimens have purposely been made longer than is necessary for the tension test and this extra length will be cut off the specimens before testing and made available for film studies.

Committee B-3 is heartily in favor of a proposal made during the year to encourage *Metals and Alloys* to do general abstracting work on the subject of corrosion.

The special funds of the committee are meeting the necessary expenses of the large field program very nicely. Approximately $4100 remains for the years to come.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 43 members; 28 members returned their ballots, all of whom voted affirmatively.

Respectfully submitted on behalf of the committee,

T. S. FULLER,
Chairman.

SAM TOUR,
Secretary.

REPORT OF SUBCOMMITTEE VI ON ATMOSPHERIC CORROSION

ATMOSPHERIC CORROSION TEST PROGRAM

A list of the metals and alloys included in the atmospheric corrosion tests being conducted by Subcommittee VI is given below, together with the laboratory in which the physical tests were made:

IDENTIFICATION LETTER	MATERIAL	SUPPLIED BY	TESTED BY
A	Commercial Copper (Tough Pitch)	American Brass Co	American Brass Co.
B	Commercial Copper (Phosphorized)	American Brass Co	Chase Metal Works
C	Cu-Si-Mn Alloy	American Brass Co	American Brass Co.
D	Tin Bronze	American Brass Co	Scoville Manufacturing Co.
F	Aluminum Bronze	American Brass Co	Bridgeport Brass Co.
G	Commercial Aluminum	Aluminum Company of America	Aluminum Company of America
I	Al-Mn Alloy	Aluminum Company of America	Aluminum Company of America
K	Manganese Bronze	American Manganese Bronze Co	American Manganese Bronze Co.
L	Brass (85–15)	Bridgeport Brass Co	Bridgeport Brass Co.
M	Brass (70–30)	Chase Metal Works	Chase Metal Works
N	Admiralty Metal	Scoville Manufacturing Co	Scoville Manufacturing Co.
O	Duralumin	Aluminum Company of America	Aluminum Company of America
P	Cu-Ni-Zn Alloy	American Brass Co	American Brass Co.
Q	Cu-Ni-Sn Alloy	Scoville Manufacturing Co	Scoville Manufacturing Co.
S	Nickel-Copper Alloy	International Nickel Co.	International Nickel Co.
T	Commercial Nickel	International Nickel Co.	International Nickel Co.
U	Chemical Lead	National Lead Co	National Lead Co.
Z	Al-Mg-Si Alloy	Aluminum Company of America	Aluminum Company of America
AA	Commercial Zinc (Prime Western)	New Jersey Zinc Co	New Jersey Zinc Co.
BB	Commercial Zinc (High Grade)	New Jersey Zinc Co	New Jersey Zinc Co.
CC	Lead Antimony Alloy	National Lead Co	National Lead Co.
EE	Commercial Tin	National Lead Co	National Lead Co.
FF	Aluminum-Coated Duralumin	Aluminum Company of America	Aluminum Company of America
HH	Zinc (99.99+per cent)	St. Joseph Lead Co	St. Joseph Lead Co.

A detailed description of the composition and physical character of these materials appears in the main report of Committee B-3.

The committee's present plan contemplates continuing the exposure tests for approximately twenty-five years. The amount of corrosion undergone by each metal and alloy is to be measured in two ways:

1. Determining the change in weight of plate specimens.
2. Determining the loss in strength and ductility by means of tension tests.

An investigation of the films of corrosion products which form on the various metals and alloys will be conducted by the Division of Metallurgy of the U. S. Bureau of Standards under the direction of H. S. Rawdon. It is hoped that this study will yield valuable information regarding the formation and character of protective and non-protective films.

The materials are exposed in the form of plates 9 by 12 in., 0.035 in. thick and tension test specimens of the same materials machined to conform with the standard A.S.T.M. specimen for sheet materials.[1] However the grip sections of the tension test specimens have been lengthened in order to overcome certain objections to the method of mounting the specimens in the exposure racks. The excess grip length does not interfere in any way with the tests since the specimens are cut to standard length before testing. The surfaces of the plates and tension test specimens were left in the original condition as received from the rolling mills and given no special preparation other than to remove with benzine, ether, and alcohol all traces of the rolling mill lubricants.

There are four plate specimens of each material exposed at each test location, two designated as "removable," two as "permanent." Thirty tension test specimens of each material under test are also exposed at each test location. In addition, an extra set of thirty tension test specimens of each material was prepared and placed in air-tight glass containers and stored at the U. S. Bureau of Standards.

At various times during the twenty-five year period the two "removable" plate specimens of each material will be taken from their racks and returned to the Bureau of Standards at Washington, D. C. for inspection and weighing. The corroded plate specimens will be weighed just as they are received from the test racks without attempting to remove any surface deposits or films of corrosion products. A set of six tension test specimens of each material will also be removed from the racks and tested to determine their tensile strength and elongation. At the same time six tension test specimens of each material will be removed from the set stored in the air-tight containers at the Bureau of Standards and their tensile properties determined coincidentally with the specimens which have been corroded in the atmosphere. These latter tests must be made in order to determine what changes may have taken place in the physical properties of the materials through simple aging so that allowances can be made for such changes in interpreting the tensile data secured from the corroded specimens.

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[1] Tentative Methods of Tension Testing of Metallic Materials (E 8 - 27 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

After weighing and inspection, the "removable" plate specimens are to be returned to the various test locations for further exposure. In transporting the plate specimens back and forth from the test locations, they will be shipped in specially designed containers to insure minimum damage to the corrosion films formed on the surface of the specimens. To make sure of the exact identity of each plate and tensile specimen, a number was stamped on each one with steel dies. With the assistance of printed forms a record was made of the exact position of each specimen in the individual specimen racks which are identified by numbered brass tags attached to them.

Before starting the program of exposure tests, it was necessary, of course, to determine the original weight of each plate specimen, after all extraneous dirt had been removed by scrubbing with solvents as previously described, and to measure carefully the thickness and width of the test section of each individual tension test specimen. The original tensile properties of the various materials under test were also determined. It is realized that the test section dimensions will change as the material is corroded in the atmosphere. Since it would be extremely difficult with some materials to determine the exact dimensions of corroded specimens, it was decided to use the original cross-sectional area of the section before exposure in all cases in calculating the tensile strength from the breaking loads of the corroded specimens.

The first test period will end in August, 1932. The length of the other test periods has not been definitely decided upon although the second removal of test specimens will probably take place at the end of three years' exposure and the others after ten, fifteen, and twenty-five years' exposure.

The large number of specimens involved in these tests made their preparation, weighing, measuring, and testing an extremely arduous task and has required the recording of an unusually large amount of detail data on special printed forms. To insure the permanence of these records they have been prepared in triplicate and one copy filed at the Society's headquarters in Philadelphia.

DESCRIPTION OF EXPOSURE RACKS

Since the atmospheric corrosion tests may continue for twenty-five years, it was necessary to select a fairly permanent type of construction for the specimen racks and supporting structure. The individual specimen racks and the main framework on which they are mounted were therefore built of structural steel protected by a heavy coating of zinc applied by the hot-dip galvanizing process. All fittings, nuts, bolts, etc., used in assembling the test racks were likewise hot-dip galvanized.

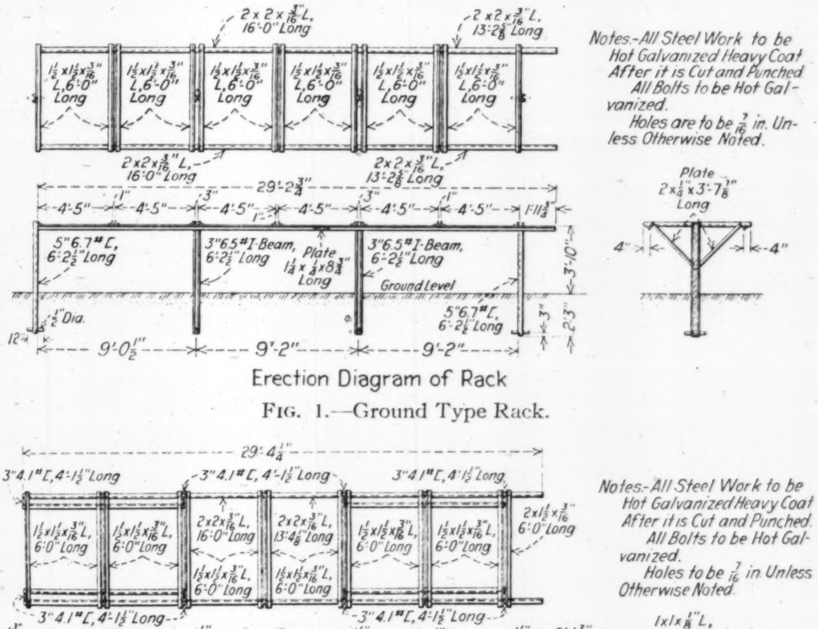
2 x 2 x $\frac{3}{16}$" L, 16'-0" Long
2 x 2 x $\frac{3}{16}$" L, 13'-2$\frac{5}{8}$" Long
1$\frac{1}{2}$ x 1$\frac{1}{2}$ x $\frac{3}{16}$" L, 6'-0" Long
Notes.-All Steel Work to be Hot Galvanized Heavy Coat After it is Cut and Punched. All Bolts to be Hot Galvanized. Holes are to be $\frac{7}{16}$ in. Unless Otherwise Noted.
29'-2$\frac{3}{4}$"
4'-5"
1"
3"
1'-11$\frac{3}{4}$"
Plate 2 x $\frac{1}{4}$ x 3'-7$\frac{7}{8}$" Long
5" 6.7# Ľ, 6'-2$\frac{1}{2}$" Long
3" 6.5# I-Beam, 6'-2$\frac{1}{2}$" Long
Plate 1$\frac{1}{4}$ x $\frac{1}{4}$ x 8$\frac{3}{4}$" Long
Ground Level
3'-10"
4"
$\frac{1}{2}$" Dia.
12"
9'-0$\frac{1}{2}$"
9'-2"
3"
2'3"
Erection Diagram of Rack

FIG. 1.—Ground Type Rack.

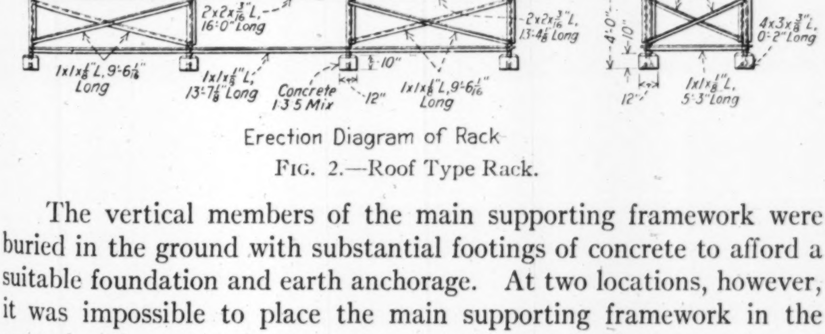
29'-4$\frac{1}{4}$"
3" 4.1# Ľ, 4'-1$\frac{1}{2}$" Long
1$\frac{1}{2}$ x 1$\frac{1}{2}$ x $\frac{3}{16}$" L, 6'-0" Long
2 x 2 x $\frac{3}{16}$" L, 16'-0" Long
2 x 2 x $\frac{3}{16}$" L, 13'-4$\frac{5}{8}$" Long
2 x 1$\frac{1}{2}$ x $\frac{3}{16}$" 6'-0" Long
Notes.-All Steel Work to be Hot Galvanized Heavy Coat After it is Cut and Punched. All Bolts to be Hot Galvanized. Holes to be $\frac{7}{16}$ in. Unless Otherwise Noted.
4'-5"
1"
1$\frac{1}{2}$"
2'-1$\frac{1}{8}$"
1 x 1 x $\frac{1}{8}$" L, 5'-9" Long
1 x 1 x $\frac{1}{8}$" L, 9'-6$\frac{1}{16}$" Long
1 x 1 x $\frac{1}{8}$" L, 13'-7$\frac{1}{8}$" Long
Concrete 1:3:5 Mix
10"
12"
4'-0"
4 x 3 x $\frac{3}{8}$" L, 0'-2" Long
1 x 1 x $\frac{1}{8}$" L, 5'-3" Long
Erection Diagram of Rack

FIG. 2.—Roof Type Rack.

The vertical members of the main supporting framework were buried in the ground with substantial footings of concrete to afford a suitable foundation and earth anchorage. At two locations, however, it was impossible to place the main supporting framework in the ground and a type of structure was designed suitable for erection on the flat roof of a building. The general assembly and details of the

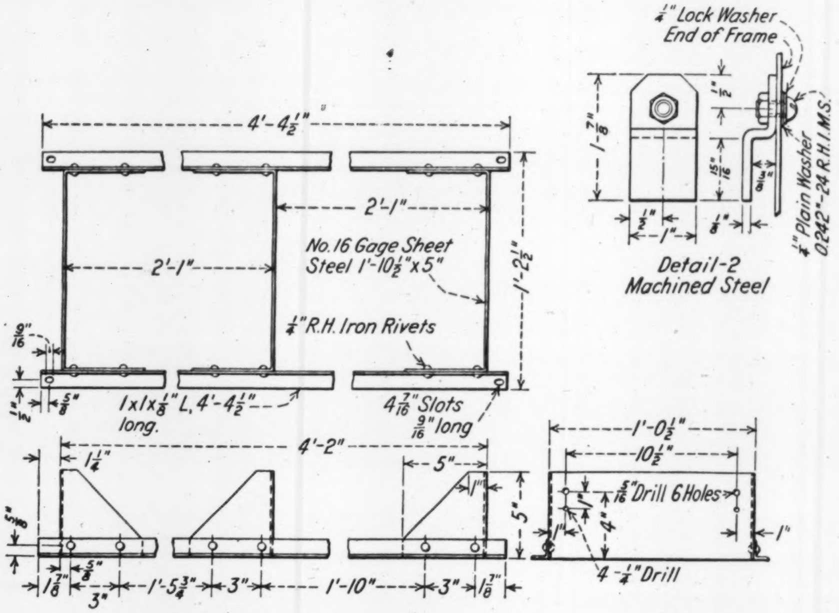
4'-4½"
2'-1"
2'-1"
No. 16 Gage Sheet Steel 1'-10½" x 5"
1'-2½"
¼" R.H. Iron Rivets
9/16"
½"
5/8"
1 x 1 x ⅛" L, 4'-4½" long.
4 7/16" Slots 9/16" long
4'-2"
1¼"
5/8"
5"
1"
5"
1⅞"
3"
1'-5¾"
3"
1'-10"
3"
1⅞"
¼" Lock Washer End of Frame
1'-⅞"
½"
15/16"
3/4"
½"
1"
⅛"
¼" Plain Washer 0.242"-24 R.H.I.M.S.
Detail-2 Machined Steel
1'-0½"
10½"
5/16" Drill 6 Holes
1"
4"
1"
1"
4-¼" Drill

FIG. 3.—Tension Test Specimen Rack.

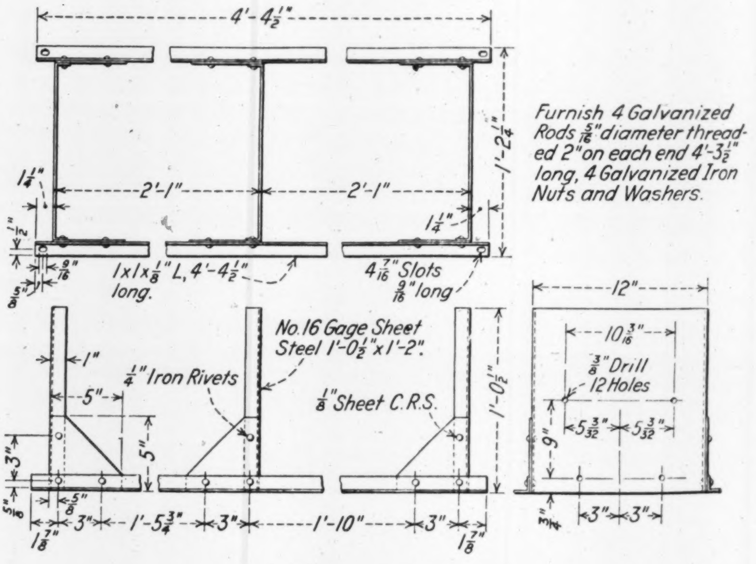
4'-4½"
1'-2¼"
Furnish 4 Galvanized Rods 5/16" diameter threaded 2" on each end 4'-3½" long, 4 Galvanized Iron Nuts and Washers.
1¼"
2'-1"
2'-1"
1¼"
½"
9/16"
5/8"
1 x 1 x ⅛" L, 4'-4½" long.
4 7/16" Slots 9/16" long
No. 16 Gage Sheet Steel 1'-0½" x 1'-2".
1"
¼" Iron Rivets
⅛" Sheet C.R.S.
1'-0½"
5"
5"
3"
5/8"
5/8"
1⅞"
3"
1'-5¾"
3"
1'-10"
3"
1⅞"
12"
10 3/16"
3/8" Drill 12 Holes
9"
5 3/32"
5 3/32"
3/4"
3"
3"

FIG. 4.—Plate Specimen Rack.

construction of these two types of structures for supporting the individual specimen racks are shown in Figs. 1 and 2.

The individual specimen racks are of two types, one rack designed to support the tension test specimens, the other to support the 9 by 12-in. plate specimens. The detailed construction of these specimen racks is shown in Figs. 3 and 4.

The tension specimens are mounted in each specimen rack on two vitreous enameled steel rods running the entire length of the rack. The rods pass through holes in each end of every tension specimen and the latter are separated from each other and spaced the proper distance apart by short lengths of phenol fiber tubing, $\frac{15}{16}$ in. long, threaded over the rods and placed between each specimen. The rods themselves are supported by passing them through holes in the steel end plates and middle partition and are prevented from slipping out of the rack by special fittings fastened to the end plates. The grip sections of the tension specimens were purposely made longer than the standard length to avoid any possible effect on the test sections of the moisture, dust, and abnormal accumulations of corrosion products which might be concentrated on the specimens adjacent to the supporting rods and fiber tube spacers. The method of placing the specimens on the racks and the mounting details are illustrated in Fig. 5.

The plate specimens are placed in a vertical position on the test racks, each plate supported by six grooved porcelain insulators strung on galvanized steel rods. The plate specimens are mounted 3 in. apart and the porcelain insulators supporting the plate are kept properly spaced by short lengths of porcelain tubing strung on the rods between the insulators. The ends of the galvanized steel rods are threaded and they are held in position in the racks by a nut and washer placed at each end of the rod. These details of construction and the method of mounting the specimens are shown in Fig. 6.

This method of supporting the plate specimens in the grooves of porcelain insulators avoided contact with any other metal and the possibility of couple-corrosion. Since the area of the plate in contact with the supporting insulators is very small, the drainage of moisture from the surface of the sheet is not interfered with and the possible effect of the collection of dust and corrosion products at the points of support on the corrosion of the specimen itself, is reduced to minimum.

Description of Atmospheric Conditions at Each Test Location

In selecting locations for the exposure tests, an effort was made to secure a wide variety of atmospheric conditions which, at the same time, would be fairly representative of the atmospheres in which the metals and alloys included in these tests are used in large percentages.

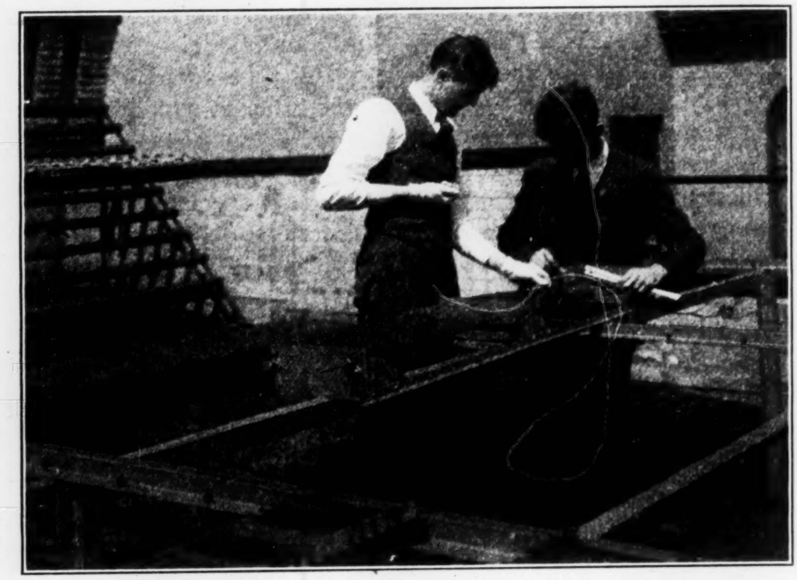

FIG. 5.—Method of Mounting Tension Test Specimens.

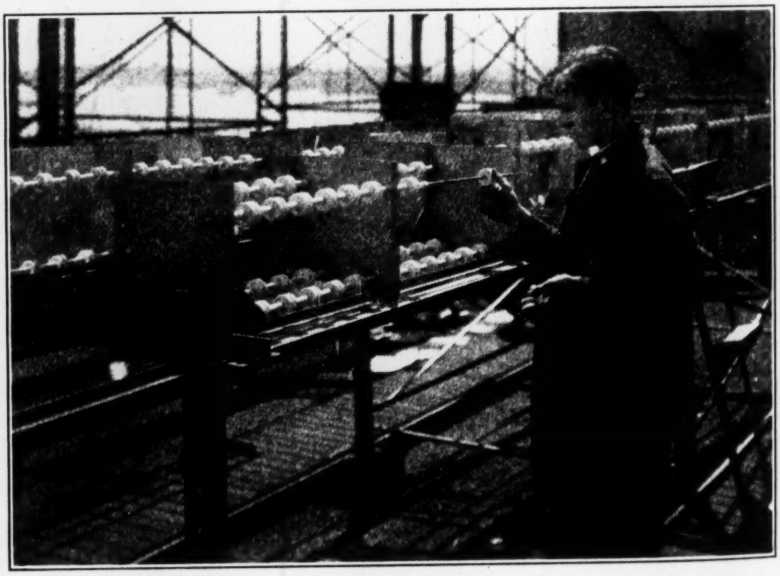

FIG. 6.—Method of Mounting Plate Specimens.

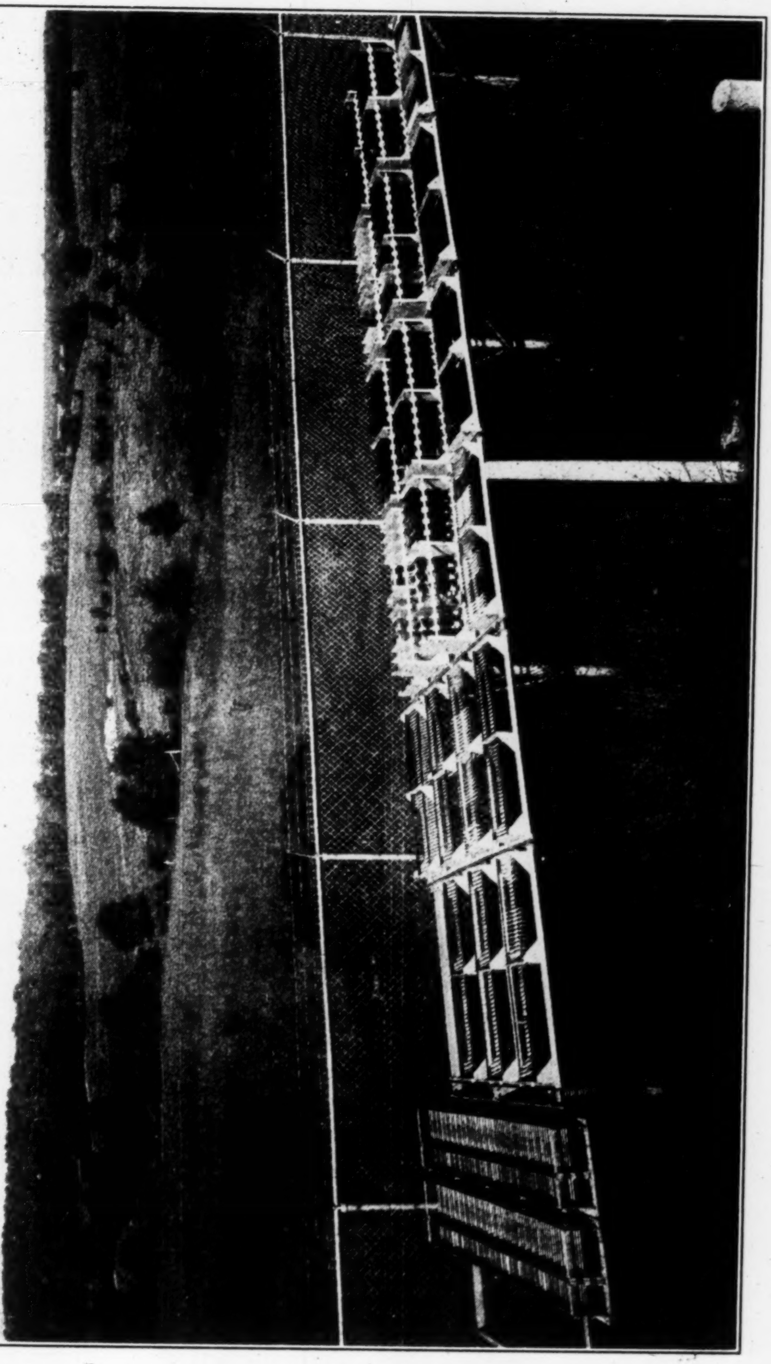

FIG. 7.—Test Rack at State College, Pa.

The types of atmosphere included in the nine test locations can be broadly classified as industrial, rural, and seacoast. There is considerable variation between the atmospheric conditions at the individual locations included in any one of the foregoing groups, and therefore these general classifications have only a broad significance. It is also appreciated that the severity of the atmospheric attack will vary considerably even within the immediate neighborhood of a test location. Differences in elevation, variations in exposure to prevailing air currents, and the amount of atmospheric pollution in the form of industrial gases can all be found to vary widely between two locations only half a mile apart. It is essential that these facts should be clearly kept in mind in interpreting and using the corrosion data resulting from these tests.

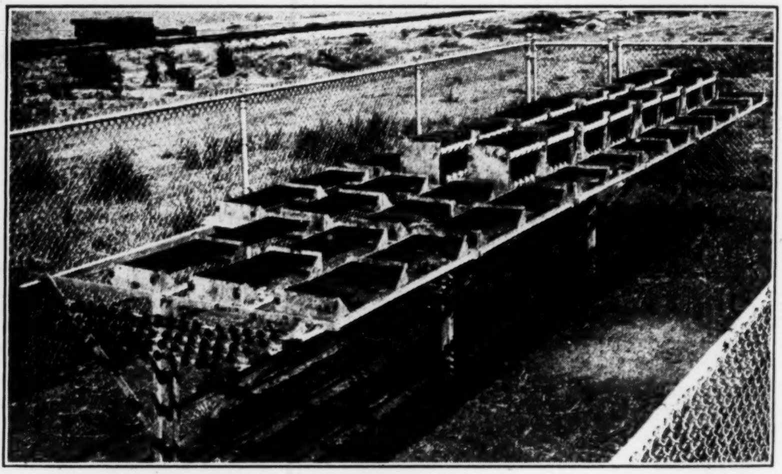

FIG. 8.—Test Rack at Phoenix, Ariz.

A brief description of each test location is given in the following paragraphs.

Rural Exposures:

State College, Pa.—This location is fairly typical of rural atmospheric conditions in the northern part of the United States, east of the Mississippi. The exposure rack is located on the experimental farms of the Pennsylvania State College approximately four miles from the college proper. With the exception of one farm house, there are no nearby habitations. The locality has an average rainfall and its general atmosphere is unusually free from contamination by industrial gases since there are no large industries of any character within ten miles of the exposure test. A photograph of this location is shown in Fig. 7.

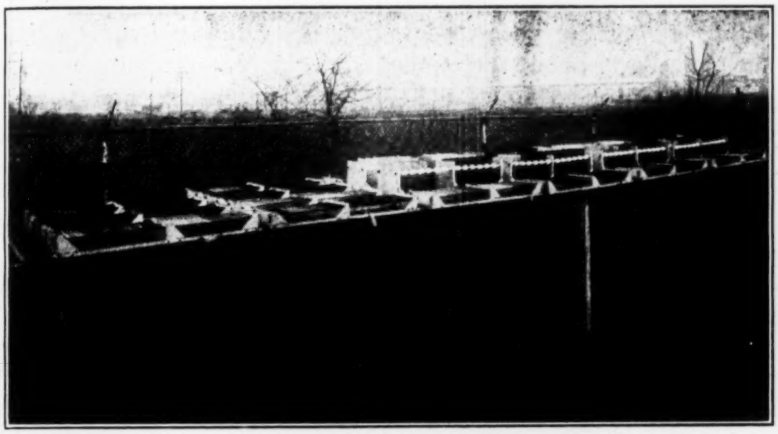

FIG. 9.—Test Rack at Pittsburgh, Pa.

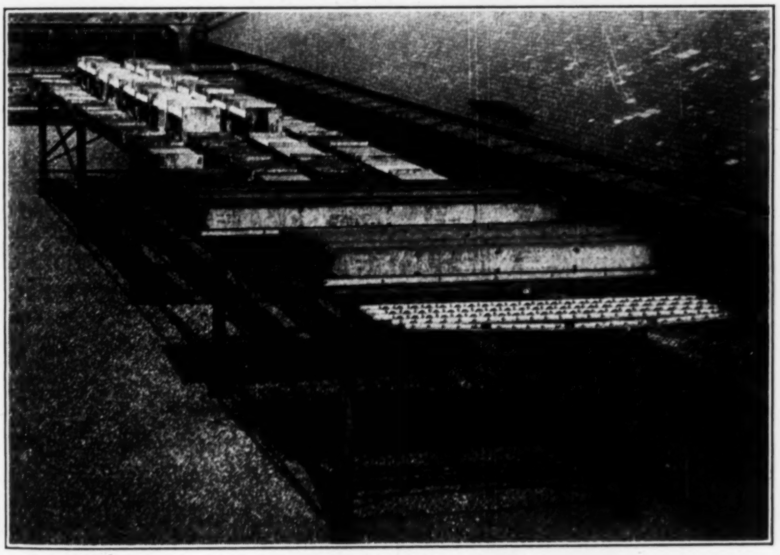

FIG. 10.—Test Rack at Altoona, Pa.

Phoenix, Ariz.—This location, although classified as rural, is unlike most of the other rural districts in the United States. The climate is hot and dry with very little rainfall and is fairly representative of the dry and semi-arid sections of the southwestern part of the country. The exposure rack is located on the properties of the Phoenix Light and Power Co. on the outskirts of the city. This location is illustrated in Fig. 8.

Industrial Exposures:

Pittsburgh, Pa.—The exposure rack is located on Brunot's Island in the Ohio River about three miles from the center of Pittsburgh, on the property of the Duquesne Light Co. The atmosphere is representative of many large manufacturing communities and is contaminated by smoke and industrial gases from factories and steel mills on both banks of the river a short distance away as well as by the stack gases from the large power generating station of the above company, located on the island. The Pittsburgh area is subject to heavy fogs, particularly during the late fall, winter and early spring months. The humidity throughout the year in this district is fairly high and even more pronounced at the exposure rack since it is located only a few feet above the river and close to the water's edge. The rainfall is about average for the region. A photograph of this location is shown in Fig. 9.

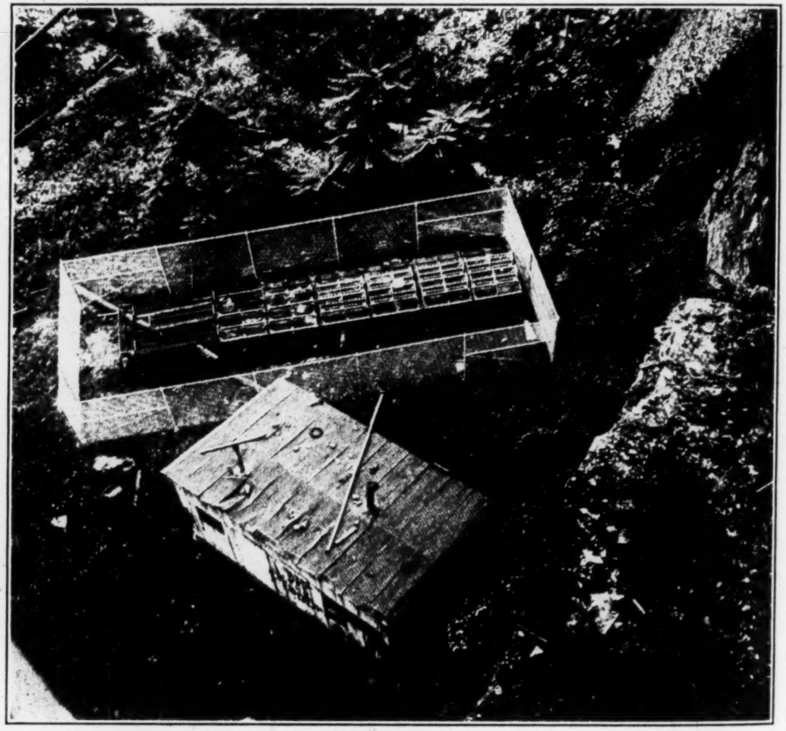

FIG. 11.—Test Rack at Rochester, N. Y.

Altoona, Pa.—As suitable ground space was not available at this location the exposure rack was placed on the flat roof of a storehouse building of the Pennsylvania Railroad Shops. Although this community is not a large industrial center, the atmosphere here is perhaps more heavily contaminated than at Pittsburgh because of the close proximity of the test rack to the busy railroad yards and forge shops, both sources of large quantities of smoke and gases from the combustion of soft coal in many locomotives and furnaces. The region receives about the same rainfall as Pittsburgh. An illustration of the exposure test is given in Fig. 10.

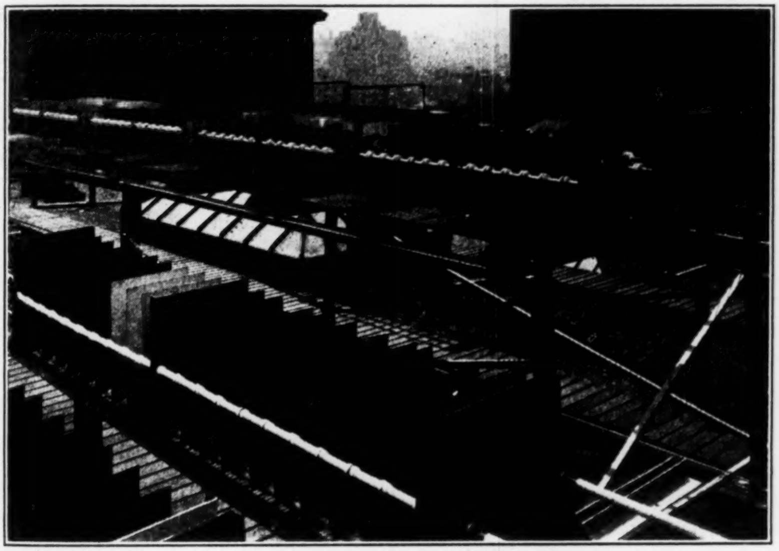

Fig. 12.—Test Rack at New York City.

Rochester, N. Y.—The test rack is on the property of the Rochester Gas and Electric Co. and is located in the gorge of the Genesee River a short distance below the falls. The humidity at this particular point is high because of the spray and mist from the water falls. The atmosphere is also contaminated by waste gases from an illuminating gas plant and various other factories located in the gorge along the river. Although the average annual precipitation is not high, yet there are many cloudy and rainy days during the year with heavy snowfall in the coldest winter months. A photograph of the location is shown in Fig. 11.

New York City.—The atmosphere of New York City is more nearly of an industrial type than is generally realized. Not only

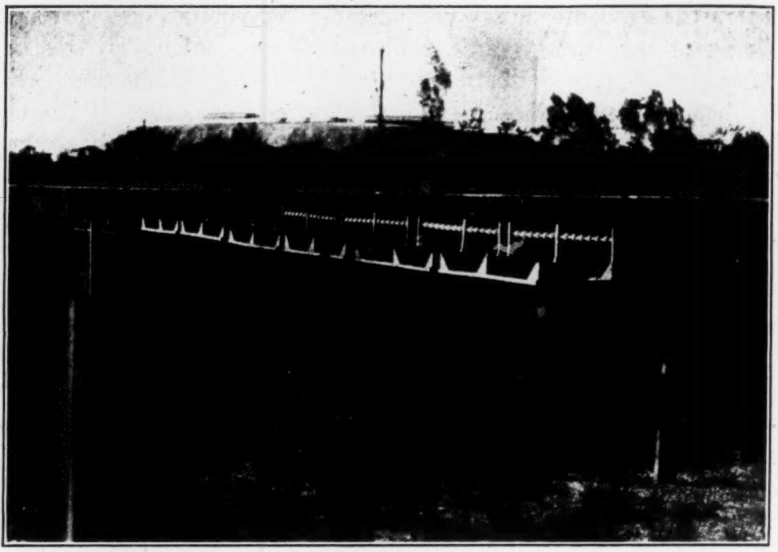

FIG. 13.—Test Rack at Sandy Hook, N. J.

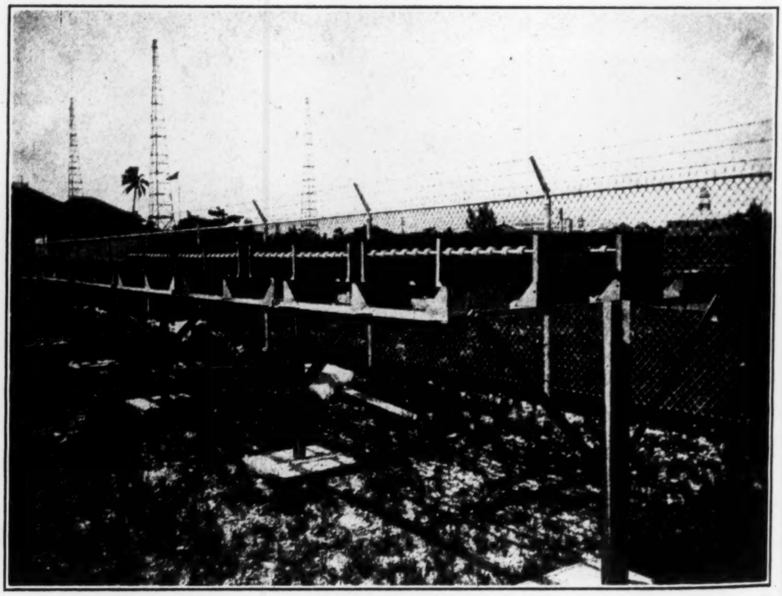

FIG. 14.—Test Rack at Key West, Fla.

is the air seriously contaminated by gases resulting from the combustion of large quantities of fuel in the many big buildings, power and steam generating stations, factories, and apartment houses concentrated on the island of Manhattan, but it is also polluted to a considerable extent by the gaseous atmosphere of the surrounding industrial districts of Long Island City, Brooklyn, Staten Island, Jersey City, and the entire metropolitan area.

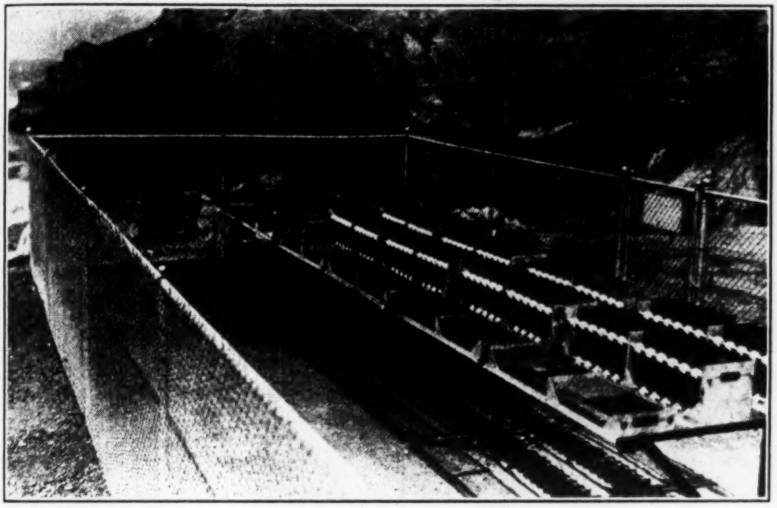

FIG. 15.—Test Rack at La Jolla, Calif.

FIG. 16.—Test Rack at La Jolla, Calif.

The exposure rack is located on the roof of the Bell Telephone Laboratories building on West St., directly opposite large steamship docks in the Hudson River. The atmosphere in the immediate vicinity receives considerable additional smoke contamination from the steamships tied up at the docks and from tugs and other vessels in the heavy river traffic passing this point. Other climatic details are given in the summary table. A general view of the test rack is shown in Fig. 12.

TABLE I.—SUMMARY OF METEOROLOGICAL DATA.

Location	Elevation, ft.	Temperature, deg. Fahr.					Precipitation, in.				Snowfall, in., melted	Relative Humidity, per cent			Sunshine		Wind	
		Mean Annual	Number of Days				Average Yearly	Highest Yearly	Lowest Yearly	Average Number of Days per Year of 0.01 in. or Over		Morning	Noon	Evening	Average Yearly Total, hours	Percentage of Possible	Average Hourly Velocity, miles	Prevailing Direction
			Maximum Temperature		Minimum Temperature													
			32° F. and Below	90° F. and Above	32° F. and Below	Zero and Below												
No. 1, Pittsburgh, Pa.	842	53	35[a]	16[a]	101[a]	1[a]	36.0	50.6	22.7	149[b]	33.4	77[c]	60[c]	62[c]	d	51[a]	8.8	W.
No. 2, Altoona Pa.	1615	49	d	d	d	d	34.3	44.1	21.2	d	29.2[b]	d	d	d	d	d	d	d
No. 3, State College, Pa.	1217	48	d	d	d	d	39.2	d	d	135	47.6	d	d	d	d	d	d	W.
No. 4, New York City	150	52	24	6	93	1	42.7	58.7	33.2	126	32.7	74	59	68	2680	60	15	N.W.
No. 5, Sandy Hook, N. J.	22	52	22	4	82	d	47.5	51.2	30.8	124	19.6	78	66	74	2716	60	14	N.W.
No. 6, Rochester, N. Y.	523	48	56	7	131	4	33.3	49.9	17.0	167	79.5	74	60	70	2375	51	9	S. W.
No. 7, Key West, Fla.	22	78[b]	0[b]	8[b]	62[b]	0[b]	44.7[b]	d	d	134[b]	0[b]	81[b]	73[b]	79[b]	d	d	9[b]	W.[b]
No. 8, Phoenix, Ariz.	1108	70	0	148[e]	12	0	7.8	14.1	3.0	39	0	57	28	28	3735	84	5	d
No. 9, La Jolla (San Diego), Calif.	50	63[b]	0	1	0	d	11.7[a]	d	d	50[a]	0	80[f]	73[b]	70	3046	70	5[b]	W.

[a] For 1930 only.
[b] For 1929 only.
[c] Average daily for 1929 only.
[d] Not published.
[e] 78 days 100° F. and over, 31 days 105° F. and over. Highest recorded temperature 117° F.
[f] May to October, Relative Humidity 80 or above, June, July, August, September, 86 to 88.

Sea Coast Exposures:

Sandy Hook, N. J.—The general atmospheric conditions at this location are fairly representative of sea coast exposures along the north Atlantic seaboard. The test rack is on Government property at Fort Hancock and placed almost at the extreme tip of the Hook jutting out into the bay, within a hundred yards of the water line, close enough to receive some salt spray from the breaking waves during severe northeast storms. The rainfall and other climatic conditions are about the same as New York City. A general view of the test rack is shown in Fig. 13.

Key West, Fla.—The exposure rack is on the property of the U. S. Government Naval Station and is located within a short distance of the water's edge. The atmosphere here is typical of sea coast conditions along the south Atlantic coast line. The climate is milder than at Sandy Hook, the average temperature higher, and the rainfall heavier. The exposure rack is shown in Fig. 14.

La Jolla, Calif.—The test rack, located on the property of Scripps Institution of Oceanography, University of California, is placed on the brow of a low bluff a few hundred feet from the water's edge. While in general this sea coast location is similar to those on the eastern seaboard, the corrosion of metals is known to be very much more rapid here than at ordinary seashore exposures elsewhere. This may be due to the unusually heavy nightly dew falls which are characteristic of this particular region along the Pacific coast. A photograph of the rack is shown in Figs. 15 and 16.

Some idea of the different atmospheric conditions at the various test locations can be had from the summary of meteorological data given in Table I compiled from the records of the nearest weather bureau stations. The various items in the table are given as the mean of the yearly averages in most cases. The period covered by the records available at each location varies, but generally it is of sufficient length to be acceptable as an index of the character of the weather at the test locations.

ACKNOWLEDGMENTS

Subcommittee VI wishes gratefully to acknowledge the very material assistance the committee has received from the following companies and agencies who not only granted permission to place test racks on their properties but also handled the erection of the test racks and installation of the specimens:

Central Arizona Light and Power Co., Phoenix, Ariz.
Scripps Institution of Oceanography of the University of California, La Jolla, Calif.
Southern California Telephone Co., Los Angeles, Calif.
Rochester Gas and Electric Co., Rochester, N. Y.
Pennsylvania Railroad, Altoona, Pa.
Bell Telephone Laboratories, Inc., New York City.

The Division of Metallurgy of the U. S. Bureau of Standards has greatly assisted the carrying out of the committee's program by taking over the cleaning and weighing of the plate specimens.

It also wishes to acknowledge the kind assistance received from the Society's Committee A-5 on Corrosion of Iron and Steel in allowing the committee to locate its test racks inside the Committee A-5 test enclosures at Pittsburgh, State College, Sandy Hook and Key West.

The committee also deeply appreciates the help received from the following individuals in installing test specimens at various locations and for the personal interest taken in the test program:

H. S. Rawdon, Chief, Division of Metallurgy, U. S. Bureau of Standards, Washington, D. C.
L. K. Doutrick, Chief Engineer, Central Arizona Light and Power Co., Phoenix, Ariz.
H. W. Hitchcock, Southern California Telephone Co., Los Angeles, Calif.
T. W. Vaughan, Director, Scripps Institution of Oceanography of the University of California, La Jolla, Calif.
L. M. Pierce, U. S. Naval Station, Key West, Fla.
L. Shnidman, Laboratory Director, Rochester Gas and Electric Co., Rochester, N. Y.
R. H. Berggren, Southern California Telephone Co., Los Angeles, Calif.
C. L. Hippensteel, Bell Telephone Laboratories, Inc., New York City.
A. W. Tracy, Research Assistant, American Brass Co., Waterbury, Conn.
L. P. Somers, Aluminum Company of America, New Kensington, Pa.
M. E. McDonnell, Chief Chemist, Pennsylvania Railroad, Altoona, Pa.
F. C. Whitmore, Dean of the School of Chemistry and Physics, Pennsylvania State College, State College, Pa.
Max Hecht, Chief Chemist, Duquesne Light Co., Pittsburgh, Pa.

Respectfully submitted on behalf of the subcommittee,

W. H. FINKELDEY,
Chairman.

REPORT OF SUBCOMMITTEE VII ON LIQUID CORROSION

As part of the general corrosion program of Committee B-3, Subcommittee VII is obtaining data and information on the resistance of representative metals to a few common solutions. This is being done by means of field tests that are being carried out under the actual conditions existing in practice. Metal specimens are being exposed within various kinds of equipment, such as evaporators and tanks that are in actual operation handling corrosive liquids.

TABLE I.—LIST OF METALS INCLUDED IN LIQUID CORROSION TESTS.

METALS	IDENTIFICATION LETTERS	COMMON SALT TESTS	CAUSTIC SODA TESTS	HYDROCHLORIC ACID TESTS	SULFURIC ACID TESTS
Electrolytic copper	A	x	x		x
Phosphorized copper	B	x			
Copper-silicon-manganese alloy	C	x		x	x
Tin bronze	D	x	x	x	x
5 per cent aluminum bronze	E	x			
8 per cent aluminum bronze	F	x			
10 per cent aluminum bronze	H	x	x	x	x
Low-carbon nickel-chromium-iron alloy	J	x	x		x
Manganese bronze	K	x		x	x
Rich low brass	L	x	x		x
Deep drawing brass	M	x	x		x
Admiralty metal	N	x	x		x
Copper-nickel-zinc alloy	P	x	x		x
Copper-nickel-tin alloy	Q	x	x		x
Cupronickel	R	x	x		x
Nickel-copper alloy	S	x	x	x	x
Nickel	T	x	x	x	x
Chemical lead	U				x
Iron-chromium alloy	V	x			
Iron-chromium-nickel alloy	W	x	x		
Silicon cast iron	X			x	x
Leaded bronze (cast)	Y	x			x

The specimens are being immersed in solutions of sulfuric acid, hydrochloric acid, caustic soda, and common salt. Tests are being carried out against each solution in at least two locations that are in different pieces of equipment. At each location, three lots of specimens are to be exposed successively, for periods of time that will be increased progressively.

Some of the tests on the first lot of specimens are in progress now, the others will be started as soon as the racks for holding the specimens are ready for installation. The details of testing procedure

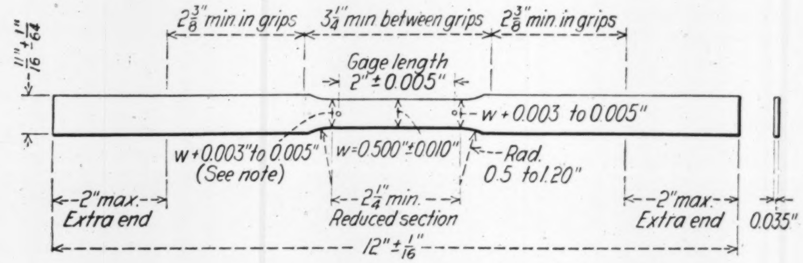
2 3/8" min. in grips
3 1/4" min between grips
2 3/8" min. in grips
Gage length 2" ± 0.005"
1 1/16" ± 1/64"
w + 0.003 to 0.005"
w + 0.003" to 0.005" (See note)
w = 0.500" ± 0.010"
Rad. 0.5 to 1.20"
2" max. Extra end
2 1/4" min. Reduced section
2" max. Extra end
0.035"
12" ± 1/16"

FIG. 1.—Standard Tension Test Specimen for Thin Sheet Metals.

NOTE.—Gradual taper from ends of reduced section to middle. All machining dimensions are shown below and testing dimensions above the specimen.

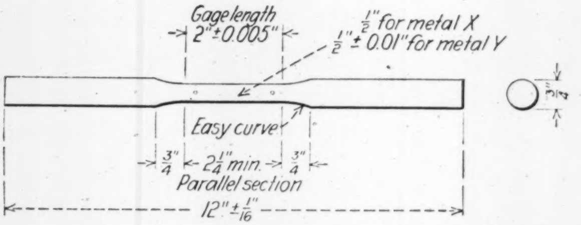
Gage length 2" ± 0.005"
1/2" for metal X
1/2" ± 0.01" for metal Y
3/4"
Easy curve
3/4"
2 1/4" min.
3/4"
Parallel section
12" ± 1/16"

FIG. 2.—Standard Tension Test Specimen for Metals X and Y.

Metal X.—All dimensions with the exception of gage length are casting dimensions. All specimens are to be used in the "as cast" condition.

Metal Y.—All dimensions with the exception of gage length are machining dimensions.

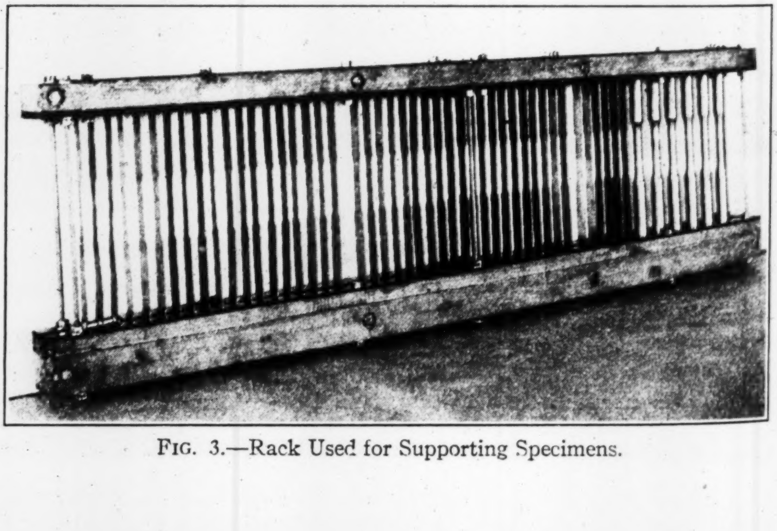

FIG. 3.—Rack Used for Supporting Specimens.

for each corrosive or the status of each test are described later in this report.

Twenty-two different metals are included in the current tests, but every metal is not being tested against every corrosive. Table I shows the list of metals, the letters used to designate each one, and which metals are being tested against each corrosive. The letter x indicates that the metal is included in the test indicated by the column heading. As the table shows, two of the metals are cast, and the others are rolled. The specimens of rolled metals conform to the dimensions shown in Fig. 1, except specimens of metals K, Q, and R

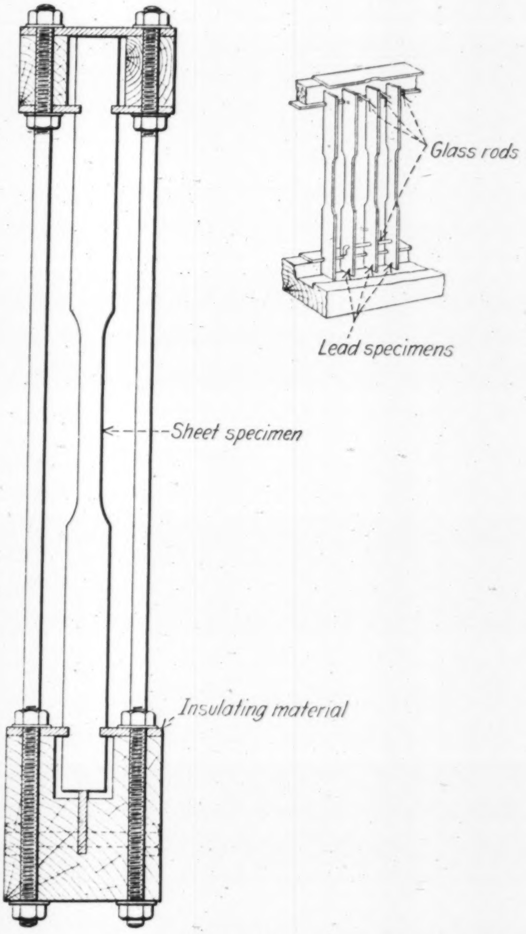

FIG. 4.—Cross-Section of Rack Used for Supporting Specimens.

which were not machined properly. The dimensions of specimens for metals X and Y are shown in Fig. 2.

Three sets of specimens are being exposed at each location, and the extent of corrosion is to be measured in terms of weight loss per unit area per unit time, also in terms of loss in tensile strength. A definite procedure has been adopted for determining the weight loss and the surface area of specimens. Tentative Methods of Tension Testing of Metallic Materials (E 8 – 27 T)[1] will be adhered to when determining tensile strength. Extra material has been provided on the ends of all specimens in case it is necessary (at the conclusion of the test) to study the microstructure, or the chemical composition of either the metal or adhering corrosion products.

At each test location, detailed information, concerning the test conditions, will be obtained and recorded. This information will include data on the chemical composition of the corrosive, the extent of aeration, temperature, and velocity.

Sulfuric Acid:

The tests with sulfuric acid as a corroding medium are being directed by Mr. W. H. Scott, The Duriron Co., Inc., who reports that tests are in progress at two locations and that a third test is being arranged for.

The type of rack used for supporting the specimens is illustrated in Fig. 3. The cross-section detail shown in Fig. 4 indicates the manner of supporting the specimens, which are insulated from each other. Some additional support had to be provided for the lead specimens. They are supported at the top as well as at the bottom of the specimens, as shown in Fig. 4.

One of these racks was put in the tank of a Grey Pickler used for pickling batches of steel sheets before tinning them. The other rack was put in the tank of a continuous pickler also handling steel sheets. In both cases, the racks were attached to the side of the tanks in such a manner that the specimens are in a vertical position, at a point well below the liquid level, but above the sludge level.

Arrangements have been made for periodic inspection of specimens and racks.

Hydrochloric Acid:

The tests using hydrochloric acid as a corrosive are in charge of Mr. T. H. Addie, who reports that tests are to be made at three locations that are being arranged for.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

There has been some delay in getting these tests started, but the test results should be available as early as the others, as more rapid corrosion is expected.

Caustic Soda:

The tests using caustic soda solutions are now in charge of Mr. B. E. Roetheli, who reports that arrangements have been made to install racks in vacuum evaporators operating, (1) for the production of commercially pure caustic, and (2) for the recovery of "black liquor" as produced in sulfate paper mills.

Preliminary tests are being made to determine what kind of insulating material will be satisfactory for use in rack construction. These tests should be completed soon, and then construction and installation of racks will follow immediately.

Respectfully submitted on behalf of the subcommittee,

R. J. McKAY,
Chairman.

H. E. SEARLE,
Secretary.

REPORT OF SUBCOMMITTEE VIII ON GALVANIC AND ELECTROLYTIC CORROSION

The corrosion testing program of Subcommittee VIII includes outdoor exposure tests at nine locations of galvanic couples of the metals in common use and complete immersion couple tests of certain metals and alloys in hot water, brine, alkali and acid.

Outdoor Exposure Tests of Galvanic Couples:

Couple combinations of all of the following metals are being subjected to outdoor exposure: aluminum, copper, mild steel, tin, zinc, nickel and lead. The outer faces of the metal disks have been protected with paint in order to confine the corrosion to the edges and the metal to metal interface. The couple assembly is illustrated in Fig. 1. The manner in which the couples are mounted on the small test rack which is installed on the Committee B-3 test fence is illustrated in Fig. 3. The couple test racks were installed at all of the test locations used by Subcommittee VI on the following dates:

Subcommittee VIII Location Number	Location	Classification	Date of Installation
1	State College, Pa.	Rural	June 8, 1931
2	Key West, Fla.	Southern sea coast	October 12, 1931
3	Sandy Hook, N. J.	Northern sea coast	April 14, 1931
4	Rochester, N. Y.	Industrial[a]	September 21, 1931
5	Altoona, Pa.	Industrial	June 1, 1931
6	New York City	Industrial (sea coast)	March 23, 1931
7	Pittsburgh, Pa.	Semi-industrial	July 8, 1931
8	Phoenix, Ariz.	Rural (dry)	September 4, 1931
9	La Jolla, Calif.	Western sea coast	September 1, 1931

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[a] Subject to spray from Genesee River Falls.

Four sets of couples have been exposed in each location. The first set will be removed at the end of one year for examination. The length of each subsequent period of exposure will be determined from the results obtained in the previous periods of exposure.

The change in weight of each metal disk will be determined for each period of exposure. These data will be supplemented with observations on the appearance of the corroded disks, noting such items as the nature of the surface attack (etching, pitting, etc.) and the amount, distribution and composition of the corrosion products. From these data an attempt will be made to classify the metals of each couple as anode and cathode and to determine the effect on the normal rate of corrosion of each metal when coupled with each of the other metals.

Complete Immersion Galvanic Couple Tests:

In the immersion tests, the couples consist of a standard tension test specimen of one metal or alloy coupled with a similar specimen of another metal or alloy. Figure 2 shows the method of coupling the two specimens together.

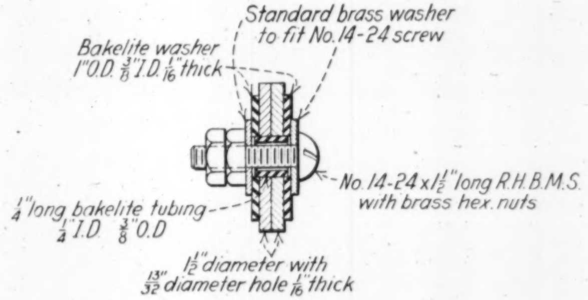
Standard brass washer to fit No. 14-24 screw
Bakelite washer 1" O.D. 3/8" I.D. 1/16" thick
No. 14-24 x 1½" long R.H.B.M.S. with brass hex. nuts
1/4" long bakelite tubing 1/4" I.D. 3/8" O.D
1½" diameter with 13/32" diameter hole 1/16" thick

FIG. 1.—A.S.T.M. Galvanic Couple for Outdoor Exposure.

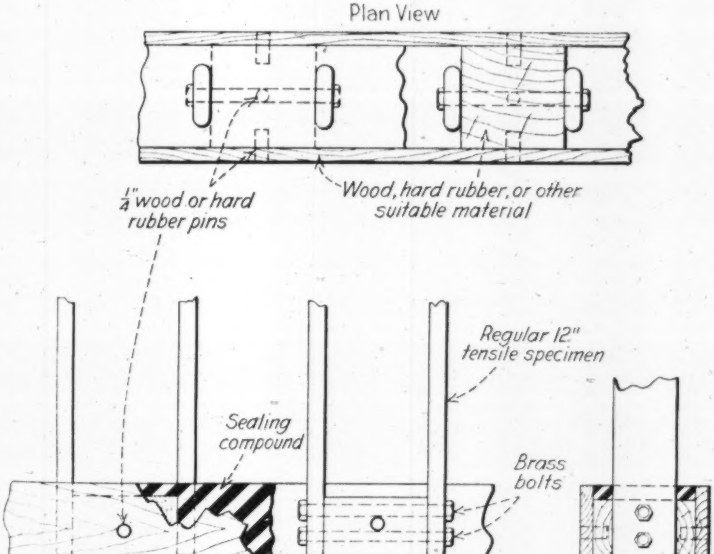
Plan View
1/4" wood or hard rubber pins
Wood, hard rubber, or other suitable material
Regular 12" tensile specimen
Sealing compound
Brass bolts
Side View
End View

FIG. 2.—Showing Protection of Coupling Used in Complete Immersion Galvanic Couple Test.

Couple combinations of those metals which have generally been used commercially under conditions of exposure similar to the test conditions are included in each of four locations. The following is a list of the couples to be exposed in the four selected locations:

Sea Water Exposure.—All couple combinations of copper, lead, brass, tin-bronze, nickel-copper alloy, cupronickel and iron-chromium-nickel alloy and all couple combinations of copper,[1] lead,[1] aluminum, iron, nickel, tin and zinc.

Sodium Hydroxide Exposure.—All couple combinations of copper, brass, nickel-copper alloy and cupronickel.

Hot Water Exposure.—All of the couple combinations exposed to the sea water test.

Sulfuric Acid.—All of the couple combinations of copper, brass, lead, tin-bronze, nickel-copper alloy, cupronickel and iron-chromium-nickel alloy.

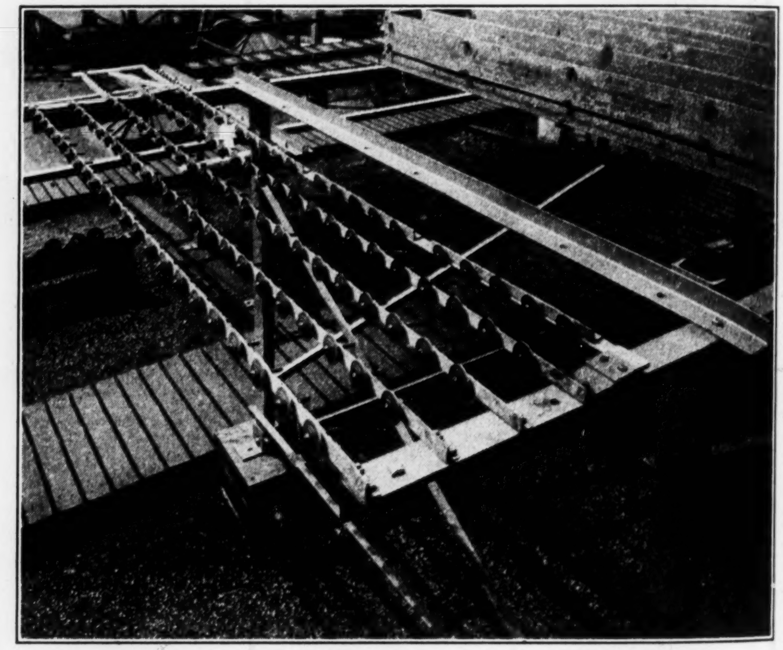

FIG. 3.—Showing Couples Mounted on the Small Test Rack.

Three sets of each couple combination will be exposed in each location. This will provide for three periods of exposure. These test periods will be spaced at fairly regular intervals and the longest period of exposure will take the least resistant materials almost to complete failure.

The weight change of each tension test specimen will be determined for each period of exposure. This will be supplemented by measurements of the change in tensile strength of each specimen and with observations on its appearance.

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[1] The copper-lead couples will not be duplicated.

From these data an attempt will be made to recommend metal combinations which can safely be used in the four types of exposure without serious galvanic couple action occurring.

The specimens are now ready to be sent to the test locations and arrangements for installation of the tests are being made.

Respectfully submitted on behalf of the subcommittee,

C. L. HIPPENSTEEL,
Chairman.

REPORT OF COMMITTEE B-4
ON
ELECTRICAL-HEATING, ELECTRICAL-RESISTANCE AND ELECTRIC-FURNACE ALLOYS

Two meetings of Committee B-4, in addition to the meeting held during the 1931 annual meeting of the Society, have been held during the year as follows: On October 12 and 13, 1931, at Washington, D. C. and on February 15 and 16, 1932, at New York City.

Four members have been added to the committee during the year and one has resigned, leaving the total membership 33, classified as 15 consumers, 15 producers and 3 general interests.

Dr. F. E. Carter has been appointed as the representative of the committee on the General Membership Committee of the Society. Mr. W. A. Gatward has resigned the chairmanship of Subcommittee III on Chemical Analysis, and Mr. T. R. Cunningham has been appointed chairman. Mr. Gatward has been the efficient chairman of this subcommittee since the organization of Committee B-4 in 1925, and has had charge of the development of the methods of chemical analysis.

A survey of the industry made during the year showed the need for standardization of methods of test for thermostatic metals. This matter was taken up with Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, the Coordinating Committee on Non-Ferrous Metals and Alloys and the Executive Committee of the Society, and it was agreed that Committee B-4 should undertake this work. A new subcommittee has therefore been organized with Mr. P. H. Brace as chairman. This subcommittee is actively at work.

The question has been raised as to the desirability of standardizing methods of test, materials and calibration curves for thermocouples and this subject has been referred to the Scientific Apparatus Makers of America for their comments. They have also been asked whether they would be willing to cooperate with Committee B-4 in this work.

Tentative Standards Continued as Tentative.—The committee recommends that the following tentative standards be continued as tentative for another year without revision:

Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 29 T);

Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 29 T);

Tentative Method of Test for Thermoelectric Power (B 77 - 30 T);

Tentative Specifications for Drawn or Rolled Alloy 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements (B 82 - 31 T);

Tentative Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements (B 83 - 31 T);

Tentative Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 - 31 T).

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Life Tests (J. W. Harsch, chairman).—It has been necessary to postpone the tests of heater wires in the radiant electric toaster unit for comparison with the accelerated life test, but it is hoped to complete these tests next year.

Subcommittee II on Electrical Tests (H. L. Curtis, chairman).—In connection with the Tentative Methods of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 - 31 T), a description is being prepared of a suitable procedure for making the resistance measurements with the required accuracy.

A method for determining the temperature coefficient of sheet resistance material, such as manganin, is being developed. A study has been made of several factors, such as the selection of samples, treatment of samples, temperature range of testing, etc.

Subcommittee III on Chemical Analysis (T. R. Cunningham, chairman).—Several changes in the Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 - 29 T) are being considered, consisting principally of a different method of solution. It was proposed that perchloric acid be used in place of nitro-hydrochloric acid in the chromium, iron, silicon and manganese determinations. A change in the method for iron was also proposed substituting a double separation with ammonium-hydroxide in place of the present method. The ascarite absorption method for carbon was proposed in place of the present volumetric method.

Subcommittee IV on Mechanical Tests (P. H. Brace, chairman).—Further progress has been made in developing the bend test for determining the elastic properties of alloys at high temperatures. Thin strips were heated to temperatures from 950 to 1800° F. while constrained to known curvatures and the temperature noted when permanent bending was obtained. Tests by two laboratories showed good agreement in the results obtained. Further tests are under way in a third laboratory, at temperatures in the upper part of the temperature range. The work is now being extended to include cast specimens of sizes used commercially. The tests are to be made at temperatures from 1200 to 1800° F.

Subcommittee V on Wrought and Cast Alloys for High-Temperature Use (C. L. Clark, chairman).—A proposed standard specimen for the tension test has been outlined, with 2-in. gage length, the bars being cast 0.010 in. over size and ground to 0.505 in. in diameter. Samples cast from one heat have been distributed to three laboratories for test at 1400, 1600 and 1800° F. Two laboratories have completed their tests.

A method of test for thermal conductivity suggested by Mr. W. N. Goodwin, Jr., of the Weston Electrical Instrument Corp. is being considered, and tests are being made in comparison with the method used at the U. S. Bureau of Standards.

A method of test for thermal coefficient of linear expansion has been outlined and is being studied. A suggested design for the apparatus for making the test has been completed.

A test specimen for determining warpage is under consideration, and samples are being prepared for test.

Subcommittee VII on Thermostatic Metals (P. H. Brace, chairman).—This new Subcommittee on Thermostatic Metals has been organized with nine members. At the first meeting there was a general review of the subject. As no standardization work has been done on this class of material, it is necessary first to define the units which will be used, and to make a survey of the methods of test required. Two sections therefore have been appointed, on Definitions and Test Methods, respectively.

The Section on Definitions is preparing definitions for "thermostatic metals," "maximum temperature," "deflection," "force," "work," and other terms used. The Section on Test Methods is making a survey of the methods of test which are considered necessary for evaluating thermostatic metals. These sections will report at the June meeting of the committee, at which time definite plans for carrying on the work will be decided upon.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 33 members; 20 members returned their ballots, of whom 19 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee.

F. E. BASH,
Secretary.

DEAN HARVEY,
Chairman.

REPORT OF COMMITTEE B-5

ON

COPPER AND COPPER ALLOYS, CAST AND WROUGHT

Committee B-5 has held two meetings during the past year; at Chicago, Ill., on June 24, 1931, and at Cleveland, Ohio, on March 10, 1932.

As a result of the year's experience with the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 30 T) certain extensive changes were found necessary. The revised specifications were presented to the Society through Committee E-10 on Standards and were accepted for publication as tentative[1] by Committee E-10 at a meeting held on August 6, 1931, at which Committee B-5 was represented by Mr. G. H. Clamer. The tentative specifications in their revised form appear in the 1931 *Proceedings*.[2] These specifications now include a total of 20 alloys instead of 15, which have been grouped under various general classes, such as, bronze alloys, red-brass alloys, high-lead alloys. The tables, appended to the specifications containing data on approximate physical properties, examples of use, foundry manipulation and machining characteristics, have been enlarged to include the new alloys and their form changed to conform with the group system. A further revision, of a minor nature, in these specifications is recommended this year as mentioned later in this report.

Recommendations Affecting Standards and Tentative Standards

Proposed Tentative Standard.—Recently, copper water tube has been developed commercially to a point where it finds extensive application and there is now a demand for specifications covering this product. The committee accordingly recommends for publication as tentative proposed Tentative Specifications for Copper Water

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[1] In submitting these specifications to Committee E-10, the committee reported the results of the letter ballot vote as follows: 28 members returned their ballots of whom 19 voted affirmatively, 1 negatively and 8 refrained from voting.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 703 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 135.

Tube, as appended hereto,[1] prepared by Subcommittee I on Wrought Metals and Alloys.

Proposed Tentative Revision of Standards.—The committee recommends for publication as tentative the following revisions in six standard specifications under its jurisdiction:

Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11 – 18), for Copper Bars for Locomotive Staybolts (B 12 – 21) and for Seamless Copper Boiler Tubes (B 13 – 18):[2]

Section 3.—In order to secure general uniformity of practice in these several specifications covering copper in various forms, it is proposed to change the requirement for copper plus silver content from "99.880 per cent" to "99.90 per cent." It is accordingly recommended that Section 3 (*b*) of these three specifications be changed to read as follows by the addition of the italicized figure and the omission of the figure in brackets:

> (*b*) Non-arsenical Copper.—Non-arsenical copper shall have a purity of at least [99.880] *99.90* per cent, as determined by electrolytic assay, silver being counted as copper. The total of impurities other than silver shall not exceed [0.120] *0.10* per cent.

Standard Specifications for Copper Pipe, Standard Sizes (B 42 – 24):[3]

Section 3.—Change to read as follows by the addition of the italicized figure and the omission of the figure in brackets:

> 3. The copper shall have a purity of at least [99.880] *99.90* per cent as determined by electrolytic assay, silver being counted as copper.

Section 12.—It is recommended that the first sentence in Paragraph (*a*) of this section, which reads as follows, be omitted as it conflicts with the requirements of Paragraph (*b*):

> No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted.

Standard Specifications for Brass Pipe, Standard Sizes (B 43 – 24):[4]

Section 3 (b).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*b*) All pipe shall be annealed sufficiently to prevent cracking. Semi-annealed pipe, which is suitable for ordinary uses, shall be furnished [unless otherwise specified] *except that red brass pipe may be furnished hard drawn.*

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[1] See p. 682.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part I, pp. 715 to 724, incl.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 743.

[4] *Ibid.*, p. 747.

Section 4.—Change the table showing the chemical composition from its present form: namely,

	HOT PIERCED PROCESS	COLD PROCESS
Copper, per cent	59.00 – 63.00	65 00 – 68.00
Lead, maximum, per cent	0.50	0.80
Iron, maximum, per cent	0.07	0.07
Zinc	remainder	remainder

to read as follows:

	MUNTZ METAL	HIGH BRASS	ADMIRALTY METAL	RED BRASS
Copper, per cent	59.00 to 63.00	65.00 to 68.00	70.00 to 73.00	84.00 to 87.00
Lead, maximum, per cent	0.50	0.80	0.07	0.07
Iron, maximum, per cent	0.07	0.07	0.07	0.07
Tin, per cent	0.15 maximum	0.15 maximum	0.90 to 1.20	0.15 maximum
Zinc, per cent	remainder	remainder	remainder	remainder

Explanatory Note.—Add a note covering rejection for high tin content similar to the note applying to the same material in the Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29), the note to read as follows:

> NOTE.—The ideal composition for admiralty metal is 70 per cent of copper, 29 per cent of zinc, and 1 per cent of tin, and better tubes will be obtained by adhering as closely as possible to this composition, particularly as to tin. It does not, therefore, seem wise to make 1 per cent of tin the minimum but rather, in order to obtain as nearly 1 per cent as possible, to allow some variation under 1 per cent and make the minimum limit for tin 0.90 per cent. Owing to the fact that a minimum of 1 per cent tin has heretofore existed, cases will occur, until the present specifications become universal, where the tin may exceed the 1.20 per cent maximum. It is not considered that this would be harmful or should be made a cause for rejection.

Section 6.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

> (*b*) Specimens of hard-drawn red brass pipe shall be annealed previous to the hammering test.

Section 7.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

> (*b*) Specimens of hard-drawn red brass pipe shall be annealed previous to the flattening test.

Section 14.—It is recommended that the first sentence in Paragraph (*a*) of this section, which reads as follows, be omitted as it conflicts with the requirements of Paragraph (*b*):

> No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted.

Table I.—The present columns for nominal weight per foot of pipe now apply to muntz metal, high brass and admiralty metal. It is recommended that the accompanying Table I showing nominal weights per foot of red brass pipe, be added to Table I of the specifications.

TABLE I.—STANDARD WEIGHTS FOR RED-BRASS PIPE.

	RED BRASS	
SIZE OF PIPE, IN.	STANDARD PIPE NOMINAL WEIGHT, LB. PER FT. OF LENGTH	EXTRA-STRONG PIPE NOMINAL WEIGHT, LB. PER FT. OF LENGTH
⅛	0.253	0.363
¼	0.450	0.611
⅜	0.630	0.829
½	0.938	1.23
¾	1.27	1.67
1	1.79	2.46
1¼	2.63	3.39
1½	3.13	4.10
2	4.14	5.67
2½	6.00	8.66
3	8.56	11.57
3½	11.17	14.07
4	12.66	16.89
4½	14.15	20.66
5	15.85	23.18
6	18.99	32.21
7	24.63	42.43
8	30.95	48.39
9	38.03	54.34
10	45.20	61.05

Standard Specifications for Sheet High Brass (B 36 – 27):[1]

Section 1.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

> (*b*) Sheet high brass shall be furnished in two grades, described as Grade Nos. 1 and 2.

Section 3.—Change the table showing the chemical composition from its present form: namely,

Copper	64.5 to 67.5 per cent
Lead	not over 0.30 per cent
Iron	not over 0.05 per cent
Zinc	remainder
Other impurities	not over 0.10 per cent

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 768.

to read as follows:

	GRADE NO. 1	GRADE NO. 2
Copper	66 to 69 per cent	64.5 to 67.5 per cent
Lead	not over 0.07 per cent	not over 0.35 per cent
Iron	not over 0.04 per cent	not over 0.06 per cent
Zinc	remainder	remainder

Section 5.—Omit Paragraph (*a*), reading as follows, and renumber the present Paragraph (*b*) as Section 5:

5. (*a*) Analyses of separate pieces may be made by the purchaser. The copper, lead, and iron determined shall be within the following limits:

Copper	64.00 to 68.00 per cent
Lead	not over 0.35 per cent
Iron	not over 0.07 per cent

Section 6.—Change this section to read as follows by the addition of the italicized words and figures:

6. The temper of ***rolled*** sheet brass shall be designated as follows:

	REDUCTION, B. & S. GAGE NOS.
Quarter Hard	1
Half Hard	2
Three-quarter Hard	*3*
Hard	4
Extra Hard	6
Spring	8
Extra Spring	*10*

Section 7.—Change this section to read as follows by the addition of the italicized words and letters and the omission of the words in brackets:

7. *The tempers of* annealed sheet brass shall be designated as follows:

[Light] *A* Anneal
[Drawing] *B* Anneal
[Soft Drawing] *C* Anneal
D Anneal
E Anneal

Sections 8 to 11.—Change the Sections on (*A*) *Hard Brass* and (*B*) *Soft Brass* under Physical Properties and Tests to read as follows:

PHYSICAL PROPERTIES AND TESTS

(*A*) *Rolled Tempers*

8. The tension test shall be standard for all rolled tempers and acceptance or rejection shall depend only on tensile strength values given in Section 9. However, for convenience in testing, Rockwell hardness test values are also given for some thicknesses. These should be considered as approximate and informatory only.

9. The average tensile strength of two samples of rolled sheet shall be within the limits given in the following table. Rockwell hardness values corresponding to these strengths in certain thicknesses are given for informatory purposes only.

Temper	Tensile Strength, lb. per sq. in., All Thicknesses: Minimum	Tensile Strength, lb. per sq. in., All Thicknesses: Maximum	Thicknesses to Which Rockwell Values Apply, in.	Rockwell Hardness (B Scale, $\frac{1}{16}$-in. Ball, 100-kg. Load) Testing One Thickness Only: Minimum	Rockwell Hardness (B Scale, $\frac{1}{16}$-in. Ball, 100-kg. Load) Testing One Thickness Only: Maximum
Quarter Hard	46 000	56 000	Over 0.040	30	60
			0.020 to 0.040	30	56
Half Hard	53 500	63 500	Over 0.040	50	73
			0.020 to 0.040	49	71
Three-quarter Hard	61 000	71 000	Over 0.040	70	80
			0.020 to 0.040	67	77
Hard	68 000	78 000	Over 0.040	78	85
			0.020 to 0.040	75	83
Extra Hard	79 000	88 500	Over 0.040	85	89
			0.020 to 0.040	83	87
Spring	86 000	95 000	Over 0.040	88	92
			0.020 to 0.040	85	89
Extra Spring	89 500	98 500	Over 0.040	89	93
			0.020 to 0.040	86	90

(*B*) *Annealed Tempers*

10. Grain size[1] shall be the standard test for all thicknesses in annealed tempers and acceptance or rejection shall depend on grain sizes given in Section 11. However, for convenience in testing, Rockwell hardness values are given for sheet over 0.020-in. in thickness. These should be considered as approximate and informatory only.

11. The average grain size[1] of two samples of annealed sheet shall be within the limits given in the following table. For comparative and informatory purposes, corresponding Rockwell hardness values in thicknesses 0.020 in. and over are given:

			Rockwell Hardness (B Scale, $\frac{1}{16}$-in. Ball, 60-kg. Load) Testing One Thickness Only					
	Average Grain Size, mm.[1]		Thicknesses 0.020 to 0.026 in.		Thicknesses Over 0.026 to 0.040 in.		Thicknesses Over 0.040 in.	
Nominal Temper	Minimum	Maximum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
A	0.100	.....	58	..	57	..	56	..
B	0.050	0.110	68	54	67	52	65	52
C	0.035	0.070	72	59	71	57	70	57
D	0.025	0.050	75	62	74	61	75	61
E	.....	0.035	..	67	..	65	..	65

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[1] Standard rules governing the preparation of micrographs and photographic grain size standards for brass are given in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2), see 1930 Book of A.S.T.M. Standards, Part I, p. 898.

NOTE.—The data on tensile strength, grain size, and Rockwell hardness values, given in Sections 9 and 11, are based on results from a large amount of careful testing by several prominent laboratories, and are believed to be accurate. However, due to the importance of the changes made, the committee wishes to expressly point out the possible necessity for some slight revision after further actual service experience.

Proposed Revision of Tentative Standards.—The committee recommends that the following tentative specifications be revised as indicated and continued as tentative:

Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 31 T):[1]

Table I.—It is recommended that in Table I of these specifications the chemical composition of Alloy No. 16 be modified by increasing the zinc content from "0.25 per cent, maximum" to read "0.50 per cent, maximum."

Tentative Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 30 T):[2]

Section 2.—Change to read as follows by the omission of the words in brackets:

2. The tubing shall be made from copper that has been deoxidized [by means of phosphorus].

Section 7.—Add a new Paragraph (*b*) to read as follows and reletter the present Paragraph (*b*) as Paragraph (*c*):

(*b*) The material shall be capable of expanding on a hardened and ground, tapered steel pin having an included angle of 60 deg., to the following amount:

OUTSIDE DIAMETER, IN.	EXPANSION OF OUTSIDE DIAMETER, PER CENT
Up to 1, inclusive	40
Over 1	30

Withdrawal of Standard.—The committee recommends that the Standard Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21)[3] and the tentative revisions of these specifications which have been published since 1928[4] be withdrawn because this subject is properly covered by the new Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 31 T).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 703 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 135.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1010 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 140.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 664.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1115 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 916.

Tentative Revision of Standards Continued as Tentative.—The committee recommends that the schedule of tolerances on length proposed in 1930 as a tentative revision of the following three specifications[1] be continued as tentative for another year:

Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29);

Standard Specifications for Seamless 70–30 Brass Condenser Tubes and Ferrule Stock (B 55 – 25); and

Standard Specifications for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56 – 25).

Tentative Standard Continued as Tentative.—The committee has in preparation a revision of the Tentative Specifications for Sand Castings of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent (B 74 – 28 T) which it is expected will be submitted to the Society through Committee E-10 on Standards subsequent to the annual meeting.[2] It accordingly recommends that these specifications be continued as tentative.

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Copper Water Tube	23	0	8
II. PROPOSED TENTATIVE REVISIONS OF STANDARDS			
Specifications for Copper Plates for Locomotive Fireboxes (B 11 – 18)	20	1	8
Specifications for Copper Bars for Locomotive Staybolts (B 12 – 21)	20	1	8
Specifications for Seamless Copper Boiler Tubes (B 13 – 18)	20	1	8
Specifications for Copper Pipe, Standard Sizes (B 42 – 24)	20	1	8
Specifications for Brass Pipe, Standard Sizes (B 43 – 24)	23	0	8
Specifications for Sheet High Brass (B 36 – 27)	22	0	9
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 31 T)	25	0	6
Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 30 T)	23	0	8
IV. WITHDRAWAL OF STANDARD			
Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21)	25	1	5

At the meeting of the committee held in Cleveland, Ohio, on March 10, 1932, Mr. C. H. Mathewson and Mr. D. K. Crampton were reelected as chairman and secretary, respectively, for a further period of two years.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol 30, Part I, p. 1272 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 917.

[2] This revision was accepted by Committee E-10 and the revised specifications appear on p. 670. See Editorial Note, p. 263.—ED.

This report has been submitted to letter ballot of the committee which consists of 50 members; 35 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. MATHEWSON,
Chairman.

D. K. CRAMPTON,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Copper Water Tube were accepted for publication as tentative and appear on page 682.

The proposed revisions of the Standard Specifications for Copper Plates for Locomotive Fireboxes, for Copper Bars for Locomotive Staybolts, for Seamless Copper Boiler Tubes, for Copper Pipe, Standard Sizes, for Brass Pipe, Standard Sizes and for Sheet High Brass were accepted for publication as tentative and appear on pages 987 to 992.

The proposed revision of the Tentative Specifications for Seamless Copper Tubing, Bright Annealed, was accepted. The specifications in their revised form appear on page 679.

The proposed revision of the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings was accepted. Additional revisions of these specifications together with revisions of the Tentative Specifications for Sand Castings of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent, were subsequently accepted on August 11, 1932, by Committee E-10 on Standards. The specifications in their revised form appear on pages 674 and 670, respectively.

The withdrawal of the Standard Specifications for Bronze Bearing Metal in Ingot Form was approved.

REPORT OF COMMITTEE B-6

ON

DIE-CAST METALS AND ALLOYS

Committee B-6 on Die-Cast Metals and Alloys met in Chicago, Ill. in June, 1931, and in New York City in February, 1932, with an average attendance of 28. All of the subcommittees have also held meetings during the past year.

The committee has voted to continue the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 - 31 T) and for Zinc-Base Alloy Die Castings (B 86 - 31 T) in the same status for another year in view of the lack of comments from users and from the standpoint of economy in the Society's publication program. The present economic situation and the decrease in production of die castings have appeared to operate against extensive use of the tentative specifications by producers or consumers. In general, the tentative standards specify a higher quality level than has been current in general commercial production. However, one large interest has used the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 - 31 T) as a basis for the formulation of a more rigorous specification for its own use.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Aluminum-Base Die-Casting Alloys (E. E. Thum, chairman).—This subcommittee, which formulated the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 - 31 T) after analysis of the extensive research data resulting from the comprehensive program on aluminum-base die-casting alloys carried out by Committee B-6, is awaiting reactions to these tentative specifications before undertaking further specification activities.

Subcommittee II on Zinc-Base Die-Casting Alloys (W. H. Graves, chairman).—The Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 - 31 T) prepared by this subcommittee are being used by certain automobile manufacturers and active efforts are being made to secure their adoption by the Society of Automotive Engineers. The use of a grade of slab zinc of higher purity than the "High Grade" type called for in A.S.T.M. Specifications B 6 - 18 has been shown to be essential for the production of high-quality zinc-base die castings and is specified in the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 - 31 T). A revision of the Standard Specifications for Slab Zinc (Spelter) (B 6 - 18) to include a special high grade "slab zinc" with a minimum guaranteed purity of 99.99 per cent is accordingly being considered by Committee B-2 on Non-Ferrous Metals and Alloys at the request of Committee B-6. Such a grade of zinc is now being used by most producers of zinc-base die castings.

A number of new zinc-base die-casting alloys have been developed by industrial laboratories since Committee B-6 outlined its program of studies on nine selected zinc-base alloys which resulted in the limitation of the Tentative Specifications B 86 – 31 T to alloy No. XXI only. Certain of the more recent alloys appear from available data to have slightly greater stability of size and physical properties in the presence of heat and moisture although they have somewhat lower initial tensile strength than alloy No. XXI. These alloys vary from alloy No. XXI (aluminum 4 per cent, copper 3 per cent, magnesium 0.1 per cent, zinc "99.99 per cent"—balance) only in the reduction or omission of the copper or magnesium content. Committee B-6 has assigned to Subcommittee II the task of collecting and correlating the data on promising new alloys to determine whether the committee is justified in revising the Tentative Specifications B 86 – 31 T to include one or more of such alloys. This subcommittee also has under consideration the formulation of specifications for ingot alloys suitable for the manufacture of die castings.

Subcommittee III on Tin- and Lead-Base Die-Casting Alloys (F. J. Tobias, chairman).—This subcommittee has outlined a research program for obtaining data on the properties of die-cast white metals to supplement the survey presented by Mr. F. J. Tobias in the 1931 annual report of Committee B-6.[1] The subcommittee has secured one cash contribution as well as offers of cooperation from certain producers and users of die castings in the carrying out of the proposed studies preparatory to formulating specifications.

Subcommittee IV on Physical Tests of Die Castings (R. L. Templin, chairman).—This subcommittee is undertaking the design of a suitable test specimen for making fatigue tests on die castings to supplement the physical data obtained by tests on the committee's standard tension and impact specimens.[2]

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman).—This subcommittee has prepared tables showing the properties of the committee's test specimens after one year's exposure (from July, 1929 to July, 1930) at the test locations at (1) Coco Solo,

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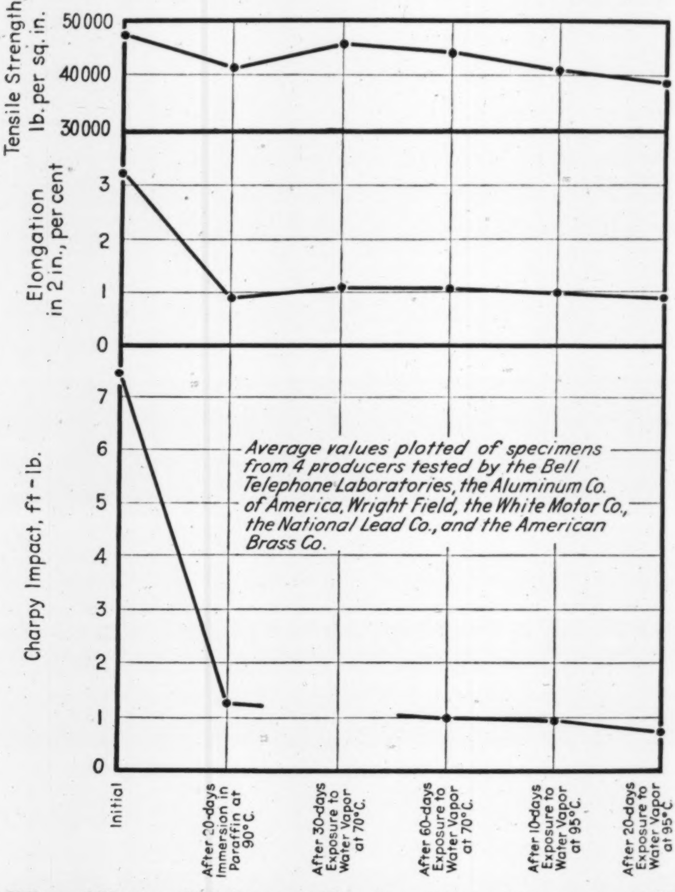
[1] Fred J. Tobias, "Lead-Base and Tin-Base Alloys for Die Castings," see *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 280 (1931).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 203 (1928).

Panama Canal Zone, (2) Hanover, N. Mex., (3) Cambridge, Mass., (4) New Kensington, Pa., (5) Altoona, Pa., (6) Rochester, N. Y., (7) Key West, Fla., (8) New York City, and (9) Sandy Hook, N. J. Tensile strength, elongation and impact data on both the aluminum and zinc-base experimental alloys as well as expansion data on the zinc-base alloys are included in Tables I to IV, appended hereto. These very valuable data afford an opportunity for the comparison of the corrosion resistance, the relative severity of various diverse cli-



Average values plotted of specimens from 4 producers tested by the Bell Telephone Laboratories, the Aluminum Co. of America, Wright Field, the White Motor Co., the National Lead Co., and the American Brass Co.

FIG. 1.—Effect of Heat and Moisture on Tensile and Impact Properties of Zinc-Base Die-Casting Alloy No. XXI.

Nominal composition of alloy No. XXI: copper 3 per cent, aluminum 4 per cent, magnesium 0.10 per cent, see A.S.T.M. Tentative Specifications for Zinc-Base Alloy Die Castings (A.S.T.M. Designation: B 86 - 31 T).

matic conditions and, together with other committee data, a comparison of accelerated laboratory tests and long-time outdoor exposure. Certain preliminary correlations on the zinc-base alloys are shown in the accompanying Figs. 1 to 4.

The superiority of alloy No. XXI to the other experimental zinc-base alloys, especially as indicated by the retention of impact strength, is apparent from the figures. Additional committee specimens now on the test racks at the above locations and also at State College, Pa. will probably be brought back in 1933 for test after four years' exposure. The last group of committee specimens will then be available for test at such subsequent date as may appear advisable. As has been stated in previous reports, these specimens were furnished through the cooperation of the foremost American producers of die castings and the testing is being carried out in various industrial and governmental laboratories under the supervision of Subcommittee V.

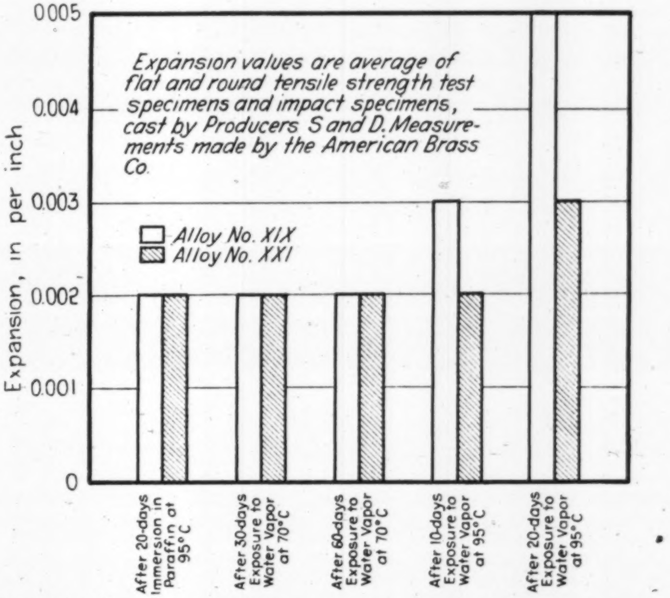


FIG. 2.—Effect of Heat and Moisture on Dimensional Stability of Zinc-Base Die-Casting Alloys Nos. XIX and XXI.

The data were obtained by measuring the total expansion in inches over the 9-in. length of the flat and round tension specimens and the 6-in. impact specimens. The average expansions were then calculated and plotted in inches per inch.

Nominal compositions of alloy No. XIX: copper 2 per cent, aluminum 4 per cent, magnesium 0.10 per cent, nickel 0.02 per cent; and of alloy No. XXI: copper 3 per cent, aluminum 4 per cent, magnesium 0.10 per cent.

Subcommittee VI on Finishing Properties of Die Castings (J. C. Fox, chairman).—This subcommittee has prepared a 40-page report on this important aspect of the satisfactory use of die castings. Although limitations of time and publication expense do not permit the publication of this report in conjunction with this annual report of Committee B-6, it is anticipated that the information will be published at a later date. Mr. Fox has discussed the better methods of application, inspection, and testing of finishes which have been developed as a result of the increased use of die-cast parts requiring finishes for protection or decoration. In addition to the recent improvements

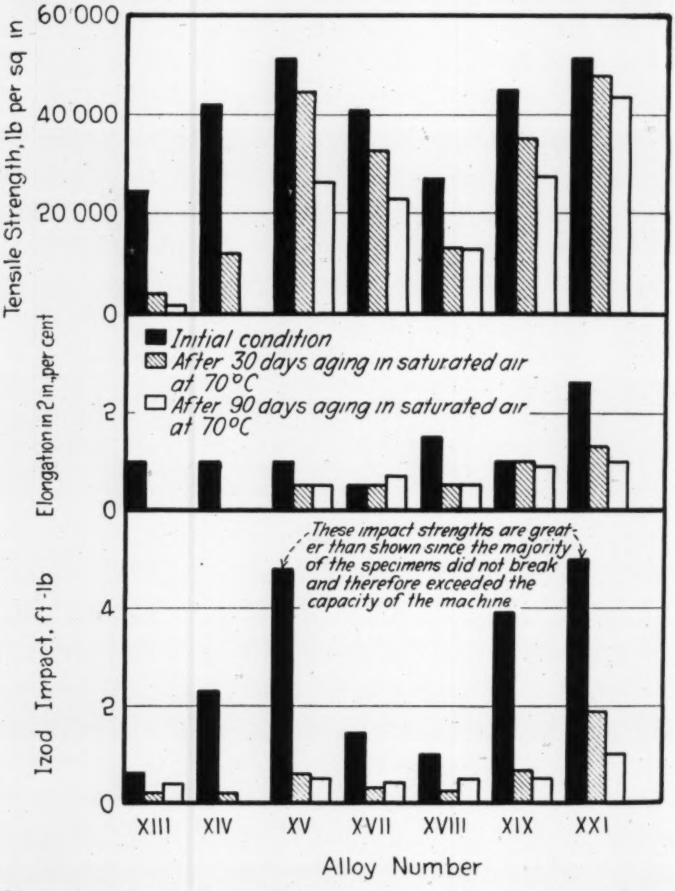


FIG. 3.—Changes in Tensile Strength, Elongation and Izod Impact of Seven Zinc-Base Alloys with Exposure to Saturated Air at 70° C. Alloys Prepared by Producer R, Tested by the Bell Telephone Laboratories.

For nominal compositions of alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

in electroplating methods, non-metallic finishes such as air-drying lacquers, synthetic-resin enamels, and baked japan finishes are applied to aluminum-base and zinc-base die castings. A smaller percentage of aluminum-base die castings are finished than in the case of zinc-base alloys, since polished and buffed aluminum die castings are satisfactory in many cases. Aluminum-copper alloys are reported to have better luster and reflectivity than aluminum-silicon alloys.

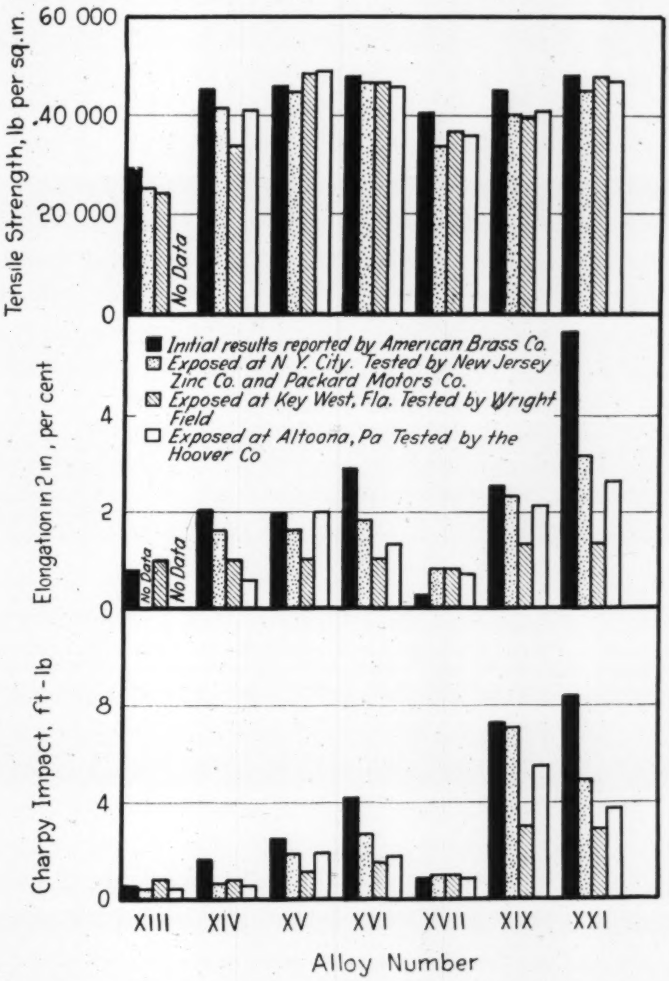


FIG. 4.—Changes in Tensile Strength, Elongation and Charpy Impact of Seven Zinc-Base Alloys After 1-Year Outdoor Exposure at Key West, Fla., Altoona, Pa., and New York City. Alloys Prepared by Producer D.

For nominal compositions of Alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

Mr. Fox reports that the strength, ductility and shock resistance of zinc-base alloy No. XXI is adversely affected when it is baked after japanning, that is, at more than 300° F. or for more than 2 hours, but that the new similar zinc alloy without copper "will withstand temperatures up to 400° F. for a maximum of 8 hours or 450° F. for 2 hours. Beyond these there is a rapid increase in permanent growth which is always objectionable." Remarkable progress has been made recently in the production of die castings with such smooth surfaces in the as-cast condition that the requisite preparation of the surface before the application of a finish is negligible.

Committee B-6 is actively following the developments in magnesium and brass die castings and expects to undertake specification activities in these fields when there is sufficient commercial justification. It is planned to arrange for the presentation of papers on these die-casting alloys and on press castings at the 1933 annual meeting. The committee is following with interest the activities of the new Subcommittee XXIII on Die Steel for Die-Casting Dies of Committee A-1 on Steel which was organized as the result of pioneer activities along this line in Committee B-6 and also the activities of the new Committee E-2 on Spectrographic Analysis now in process of organization. The high purity (99.99 per cent) of the slab zinc used in die castings and the necessity for avoiding contamination of the alloy in the die-casting plant makes the spectroscope an essential analytical tool in such plants.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 61 members; 36 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. A. ANDERSON,
Chairman.

P. V. FARAGHER,
Secretary.

APPENDIX

Table I.—Physical Properties of Aluminum-Base Die-Casting Alloy Specimens After 1-Year Outdoor Exposure.

Note.—For compositions of alloys, see reports on investigation of die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV of Committee B-2 on Non-Ferrous Metals and Alloys) see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 202 (1928); Vol. 29, Part I, p. 192 (1929); Vol. 30, Part I, p. 318 (1930); and Vol. 31, Part I, p. 261 (1931).

Alloy[a]	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Charpy Impact,[b] ft-lb.
			Round Specimen[b]	Round Specimen[b]	
No. I	C	Key West, Fla.	29 500	4.8	5.09
		Sandy Hook, N. J.	29 900	4.5	4.3
		Rochester, N. Y.	....	....	....
		Altoona, Pa.	28 200	4.66	4.58
		New York City	30 500	5.47	3.96[c]
No. I	D	Key West, Fla.	26 900	4.0	6.02
		Sandy Hook, N. J.	28 700	3.0	6.0
		Rochester, N. Y.	....	....	4.73
		Altoona, Pa.	28 300	4.6	5.93
		New York City	25 900	3.91	4.17[c]
No. I	G	Key West, Fla.	28 900	2.8	4.20
		Sandy Hook, N. J.	29 500	2.5	5.6
		Rochester, N. Y.	29 100	2.9	4.58
		Altoona, Pa.	29 500	3.66	4.53
		New York City	29 100	3.13	3.80[c]
No. I	S	Key West, Fla.	32 200	4.8	6.25
		Sandy Hook, N. J.	31 900	4.0	6.7
		Rochester, N. Y.	34 500	4.5	6.22
		Altoona, Pa.	32 400	4.7	7.29
		New York City	32 300	5.00	4.91[c]
No. I	W	Key West, Fla.	32 600	5.0	4.76
		Sandy Hook, N. J.	30 600	3.5	5.1
		Rochester, N. Y.	32 000	5.0	6.08
		Altoona, Pa.	31 900	5.00	5.44
		New York City	31 400	5.08	4.43[c]
No. IV	C	Key West, Fla.	30 500	4.5	4.44
		Sandy Hook, N. J.	29 700	3.5	4.2
		Rochester, N. Y.	31 400	4.5	4.85
		Altoona, Pa.	28 800	4.4	4.59
		New York City	31 400	4.84	3.93[c]
No. IV	D	Key West, Fla.	23 900	....	3.89
		Sandy Hook, N. J.	23 800	1.5	4.4
		Rochester, N. Y.	27 000	3.0	3.57
		Altoona, Pa.	26 800	3.0	3.72
		New York City	26 100	3.52	3.51[c]
No. IV	G	Key West, Fla.	28 300	3.7	4.24
		Sandy Hook, N. J.	28 900	3.0	5.1
		Rochester, N. Y.	30 500	3.9	4.69
		Altoona, Pa.	29 000	4.9	4.66
		New York City	29 100	3.44	3.77[c]
No. IV	S	Key West, Fla.	30 800	4.0	5.95
		Sandy Hook, N. J.	30 200	3.5	5.8
		Rochester, N. Y.	31 000	3.7	4.47
		Altoona, Pa.	29 600	4.3	5.37
		New York City	30 700	5.16	5.25[c]
No. IV	W	Key West, Fla.	31 500	1.7	2.43
		Sandy Hook, N. J.	30 800	1.5	2.5
		Rochester, N. Y.	31 900	2.1	2.62
		Altoona, Pa.	31 500	2.5	2.21
		New York City	30 200	2.34	1.96[c]
No. V	C	Key West, Fla.	32 700	1.5	1.76
		Sandy Hook, N. J.	32 600	1.0	1.5
		Rochester, N. Y.	32 700	1.4	2.47
		Altoona, Pa.	33 200	1.9	1.28
		New York City	35 300	1.95	1.50[c]

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[a] For nominal compositions of alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

[b] For sizes and shapes of tension and impact specimens, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 203 (1928).

[c] **Izod impact results. All other impact values determined in Charpy type machines.**

TABLE I.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Charpy Impact ft-lb.
			Round Specimen	Round Specimen	
No. V	D	Key West, Fla.	25 300	....	1.79
		Sandy Hook, N. J.	27 000	0.5	1.5
		Rochester, N. Y.	29 700	1.2	2.32
		Altoona, Pa.	[b]	[b]	1.69
		New York City	26 700	1.56	1.51[a]
No. V	G	Key West, Fla.	27 800	1.5	1.51
		Sandy Hook, N. J.	27 800	1.0	1.3
		Rochester, N. Y.	28 000	1.3	2.03
		Altoona, Pa.	25 500	1.6	1.54
		New York City	26 500	1.56	1.28[a]
No. V	S	Key West, Fla.	37 100	2.2	2.85
		Sandy Hook, N. J.	34 100	1.5	2.8
		Rochester, N. Y.	36 900	2.5	3.0
		Altoona, Pa.	36 400	2.8	3.00
		New York City	33 700	2.34	2.53[a]
No. V	W	Key West, Fla.	26 500	0.8	1.46
		Sandy Hook, N. J.	25 100	0	0.8
		Rochester, N. Y.	26 200	1.1	2.11
		Altoona, Pa.	25 900	1.25	0.64
		New York City	30 100	0.78	1.21[a]
No. VII	C	Key West, Fla.	34 600	3.2	2.77
		Sandy Hook, N. J.	35 500	2.5	2.9
		Rochester, N. Y.	35 500	2.9	3.29
		Altoona, Pa.	34 600	2.8	2.76
		New York City	36 900	3.29	2.43[a]
No. VII	D	Key West, Fla.	29 100	1.5	1.30
		Sandy Hook, N. J.	29 300	0	1.2
		Rochester, N. Y.	28 100	1.2	2.73
		Altoona, Pa.	29 800	1.5	1.43
		New York City	29 100	4.95	4.90[a]
No. VII	G	Key West, Fla.	27 900	1.4	2.24
		Sandy Hook, N. J.	30 100	0.5	1.7
		Rochester, N. Y.	31 000	1.9	2.52
		Altoona, Pa.	30 900	2.5	2.24
		New York City	28 700	1.72	1.73[a]
No. VII	S	Key West, Fla.	34 300	1.5	1.63
		Sandy Hook, N. J.	33 400	0.5	1.6
		Rochester, N. Y.	....	....	....
		Altoona, Pa.	34 200	1.9	1.82
		New York City	35 100	1.56	1.77[a]
No. VII	W	Key West, Fla.	27 400	1.5	1.30
		Sandy Hook, N. J.	32 100	0.5	1.1
		Rochester, N. Y.	30 000	1.3	1.72
		Altoona, Pa.	32 700	2.17	1.15
		New York City	32 500	0.78	1.20[a]
No. VIII	C	Key West, Fla.	31 300	5.9	4.45
		Sandy Hook, N. J.	30 800	5.0	3.9
		Rochester, N. Y.	31 800	6.1	5.58
		Altoona, Pa.	31 700	7.0	4.43
		New York City	32 700	7.19	3.90[a]
No. VIII	D	Key West, Fla.	26 800	5.29	3.69
		Sandy Hook, N. J.	26 000	2.0	3.2
		Rochester, N. Y.	27 800	2.9	3.62
		Altoona, Pa.	25 300	3.0	3.33
		New York City	26 700	1.56	2.80[a]

[a] Izod impact results. All other impact values determined in Charpy type machines.

[b] Bars failed in fillet.

TABLE I.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Charpy Impact, ft-lb.
			Round Specimen	Round Specimen	
No. VIII	G	Key West, Fla	26 200	2.6	4.19
		Sandy Hook, N. J	24 000	2.5	3.8
		Rochester, N. Y	30 200	3.6	3.41
		Altoona, Pa	26 000	4.0	4.00
		New York City	24 200	3.33	3.71[a]
No. VIII	S	Key West, Fla	32 600	4.4	5.19
		Sandy Hook, N. J	33 100	4.5	4.6
		Rochester, N. Y	35 300	1.5	4.60
		Altoona, Pa	32 200	5.5	4.85
		New York City	33 900	5.31	4.39[a]
No. VIII	W	Key West, Fla	29 800	5.1	6.52
		Sandy Hook, N. J	28 700	2.5	5.7
		Rochester, N. Y	30 000	5.7	6.01
		Altoona, Pa	29 000	5.7	6.30
		New York City	31 400	5.27	5.09[a]
No. IX	C	Key West, Fla	35 900	1.0	1.43
		Sandy Hook, N. J	37 200	0.5	1.1
		Rochester, N. Y	....	....	....
		Altoona, Pa	35 100	1.3	1.38
		New York City	39 500	2.08	1.30[a]
No. IX	D	Key West, Fla	28 000	1.3	1.55
		Sandy Hook, N. J	26 800	0.5	1.5
		Rochester, N. Y	30 600	1.0	2.33
		Altoona, Pa	27 500	1.9	1.24
		New York City	27 700	1.56	1.29[a]
No. IX	G	Key West, Fla	31 100	1.8	2.04
		Sandy Hook, N. J	31 500	1.0	1.7
		Rochester, N. Y	33 400	2.0	1.96
		Altoona, Pa	31 600	2.25	1.99
		New York City	32 200	1.56	1.61[a]
No. IX	S	Key West, Fla	35 400	4.1	2.12
		Sandy Hook, N. J	35 800	1.0	1.9
		Rochester, N. Y	33 600	5.5	2.59
		Altoona, Pa	34 900	2.4	2.04
		New York City	36 000	2.08	1.89[a]
No. IX	W	Key West, Fla	36 500	1.5	1.71
		Sandy Hook, N. J	37 300	1.5	1.5
		Rochester, N. Y	38 300	1.8	2.40
		Altoona, Pa	35 800	1.8	1.62
		New York City	39 200	1.56	1.52[a]
No. X	C	Key West, Fla	33 100	3.0	3.51
		Sandy Hook, N. J	32 400	2.0	3.0
		Rochester, N. Y	33 000	3.2	3.37
		Altoona, Pa	32 000	3.5	2.78
		New York City	35 400	3.75	2.30[a]
No. X	D	Key West, Fla	22 600	2.0	2.60
		Sandy Hook, N. J	23 100	1.5	2.3
		Rochester, N. Y	24 100	1.5	2.24
		Altoona, Pa	22 800	2.1	2.40
		New York City	27 700	1.87	2.04[a]
No. X	G	Key West, Fla	25 900	2.5	2.73
		Sandy Hook, N. J	26 300	2.0	2.6
		Rochester, N. Y	27 900	2.2	2.26
		Altoona, Pa	27 700	3.25	2.46
		New York City	27 400	2.18	1.94[a]

[a] Izod impact results. All other impact values determined in Charpy type machines.

TABLE I.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation, in 2 in., per cent	Charpy Impact, ft-lb.
			Round Specimen	Round Specimen	
No. X	S	Key West, Fla	32 000	3.0	3.20
		Sandy Hook, N. J	31 200	2.0	3.1
		Rochester, N. Y	31 800	2.8	2.97
		Altoona, Pa	30 300	3.0	3.12
		New York City	32 400	2.73	2.56[a]
No. X	W	Key West, Fla	29 600	2.5	2.36
		Sandy Hook, N. J	27 600	2.0	2.7
		Rochester, N. Y	29 300	2.0	2.75
		Altoona, Pa	28 800	2.5	2.93
		New York City	30 300	2.66	2.25[a]
No. XI	C	Key West, Fla	36 000	2.5	3.05
		Sandy Hook, N. J	34 800	2.0	2.7
		Rochester, N. Y	35 800	3.0	3.12
		Altoona, Pa	34 200	3.3	2.66
		New York City	36 400	3.13	2.23[a]
No. XI	D	Key West, Fla	28 800	....	3.28
		Sandy Hook, N. J	28 500	1.0	3.0
		Rochester, N. Y	28 300	2.5	3.48
		Altoona, Pa	30 200	2.3	3.07
		New York City	28 300	2.34	2.75[a]
No. XI	G	Key West, Fla	30 300	1.5	2.76
		Sandy Hook, N. J	31 000	2.0	2.7
		Rochester, N. Y	34 200	2.8	3.05
		Altoona, Pa	31 400	0.27	3.18
		New York City	30 100	1.87	2.22[a]
No. XI	S	Key West, Fla	34 600	1.5	2.12
		Sandy Hook, N. J	34 400	1.0	1.9
		Rochester, N. Y	34 600	1.4	2.27
		Altoona, Pa	32 100	2.0	1.96
		New York City	34 100	2.18	1.84[a]
No. XI	W	Key West, Fla	29 800	1.3	1.47
		Sandy Hook, N. J	29 300	0.5	1.3
		Rochester, N. Y	29 900	1.4	1.6
		Altoona, Pa	28 100	2.0	1.21
		New York City	29 100	0.78	1.24[a]
No. XII	C	Key West, Fla	33 400	2.3	2.67
		Sandy Hook, N. J	35 000	2.0	2.5
		Rochester, N. Y	33 900	2.0	3.02
		Altoona, Pa	33 300	2.0	2.44
		New York City	35 600	3.13	2.04[a]
No. XII	D	Key West, Fla	32 400	1.0	1.65
		Sandy Hook, N. J	32 900	0	1.2
		Rochester, N. Y	31 900	1.3	2.61
		Altoona, Pa	30 200	1.0	1.56
		New York City	33 000	....	1.44[a]
No. XII	G	Key West, Fla	28 800	1.8	2.51
		Sandy Hook, N. J	31 300	1.0	2.0
		Rochester, N. Y	28 500	1.6	2.52
		Altoona, Pa	31 100	2.17	2.21
		New York City	27 400	1.60	2.19[a]
No. XII	S	Key West, Fla	35 400	1.6	2.67
		Sandy Hook, N. J	37 700	1.5	2.6
		Rochester, N. Y	38 100	2.0	2.86
		Altoona, Pa	31 900	2.0	2.94
		New York City	35 900	1.78	2.47[a]
No. XII	W	Key West, Fla	31 600	1.4	1.47
		Sandy Hook, N. J	35 800	1.0	1.3
		Rochester, N. Y	32 300	1.0	2.29
		Altoona, Pa	34 500	1.9	1.36
		New York City	37 600	1.56	1.37[a]

[a] **Izod impact results. All other impact values determined in Charpy type machines.**

TABLE II.—PHYSICAL PROPERTIES OF ALUMINUM-BASE DIE-CASTING ALLOY SPECIMENS AFTER 1-YEAR INDOOR EXPOSURE.

Alloy[a]	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact,[b] ft-lb.
			Flat Specimen[b]	Round Specimen[b]	Flat Specimen[b]	Round Specimen[b]	
No. I	C	Hanover, N. Mex	21 500	28 300	3.3	4.1	4.8
		Cambridge, Mass	21 500	29 300	2.1	4.4	4.92
		New Kensington, Pa	21 300	29 100	1.4	3.9	3.91
		Coco Solo Islands	23 900	29 100	2.4	4.2	4.40
No. I	D	Hanover, N. Mex	25 700	28 300	3.9	4.3	6.9
		Cambridge, Mass	26 200	28 800	3.7	4.0	5.65
		New Kensington, Pa	27 500	27 000	3.5	3.2	4.60
		Coco Solo Islands	26 600	28 900	3.4	4.0	5.38
No. I	G	Hanover, N. Mex	26 200	29 300	2.9	3.6	3.9
		Cambridge, Mass	28 400	30 600	2.6	2.9	4.47
		New Kensington, Pa	27 900	30 500	2.5	3.6	3.25
		Coco Solo Islands	27 400	30 700	2.6	3.2	4.44
No. I	S	Hanover, N. Mex	24 200	33 700	2.9	4.5	7.0
		Cambridge, Mass	26 400	35 100	2.7	4.9	7.57
		New Kensington, Pa	24 400	35 200	1.9	4.4	6.49
		Coco Solo Islands	26 000	33 800	2.3	4.5	6.16
No. I	W	Hanover, N. Mex	29 800	32 100	4.2	3.9	5.6
		Cambridge, Mass	29 600	32 900	3.9	4.8	6.18
		New Kensington, Pa	30 500	32 600	4.1	3.4	4.35
		Coco Solo Islands	29 900	31 200	4.2	3.8	5.36
No. II	C	Hanover, N. Mex	31 900	34 500	3.3	2.4	3.6
		Cambridge, Mass	29 200	34 700	2.4	3.1	3.31
		New Kensington, Pa	31 200	37 100	2.5	3.4	2.85
		Coco Solo Islands	31 100	36 200	2.2	2.5	3.07
No. II	D	Hanover, N. Mex	29 200	35 900	1.0	1.4	2.0
		Cambridge, Mass	32 000	34 900	1.1	1.1	2.11
		New Kensington, Pa	30 200	37 400	0.3	0.8	1.56
		Coco Solo Islands	32 700	36 900	1.0	0.90	1.94
No. II	G	Hanover, N. Mex	30 800	36 900	1.9	2.2	3.5
		Cambridge, Mass	32 000	34 000	1.8	2.2	3.28
		New Kensington, Pa	28 600	35 600	1.6	1.6	3.20
		Coco Solo Islands	29 800	34 400	1.3	1.8	3.51
No. II	S	Hanover, N. Mex	25 500	37 900	1.5	2.0	2.8
		Cambridge, Mass	28 700	37 200	1.2	2.0	2.39
		New Kensington, Pa	32 300	38 600	1.0	1.3	1.95
		Coco Solo Islands	30 200	37 400	1.2	1.8	2.71
No. II	W	Hanover, N. Mex	36 600	39 300	2.0	1.9	2.0
		Cambridge, Mass	35 500	39 000	1.2	1.8	2.08
		New Kensington, Pa	35 800	37 800	1.5	1.2	1.81
		Coco Solo Islands	37 500	37 000	1.4	0.9	1.95
No. III	C	Hanover, N. Mex	36 600	38 600	1.5	1.2	1.5
		Cambridge, Mass	36 600	39 600	1.0	1.1	1.69
		New Kensington, Pa	35 500	40 100	1.2	1.1	0.99
		Coco Solo Islands	37 000	39 400	0.7	1.1	1.33
No. III	D	Hanover, N. Mex	37 500	39 700	0.7	1.0	1.3
		Cambridge, Mass	40 300	41 300	0.8	0.8	1.33
		New Kensington, Pa	37 200	39 500	0.6	0.7	1.01
		Coco Solo Islands	34 000	40 500	0.3	0.5	1.27
No. III	G	Hanover, N. Mex	31 600	39 500	1.1	1.0	1.4
		Cambridge, Mass	34 900	38 700	0.8	1.0	1.42
		New Kensington, Pa	34 300	39 800	1.0	0.9	1.17
		Coco Solo Islands	34 200	39 400	0.5	0.7	1.46
No. III	S	Hanover, N. Mex	34 200	42 900	1.0	1.0	1.7
		Cambridge, Mass	35 900	39 400	0.9	1.0	1.47
		New Kensington, Pa	35 000	41 800	1.0	0.5	1.12
		Coco Solo Islands	34 800	41 900	0.6	0.9	1.49

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[a] For nominal compositions of alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

[b] For sizes and shapes of tension and impact specimens, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 203 (1928).

TABLE II.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact, ft-lb.
			Flat Specimen	Round Specimen	Flat Specimen	Round Specimen	
No. III	W	Hanover, N. Mex	38 900	40 800	1.1	1.3	1.4
		Cambridge, Mass	38 200	37 900	1.0	0.8	1.55
		New Kensington, Pa	39 300	39 900	0.9	0.3	1.16
		Coco Solo Islands	36 700	41 000	0.7	0.5	0.95
No. IV	C	Hanover, N. Mex	28 200	30 600	4.2	4.3	4.4
		Cambridge, Mass	31 500	30 800	4.4	4.4	4.37
		New Kensington, Pa	30 100	31 700	3.1	3.9	3.76
		Coco Solo Islands	29 900	30 300	4.1	4.2	3.90
No. IV	D	Hanover, N. Mex	24 500	24 600	3.0	3.3	4.1
		Cambridge, Mass	25 900	25 900	2.8	2.7	3.97
		New Kensington, Pa	26 400	25 900	3.3	2.0	3.36
		Coco Solo Islands	25 400	25 500	2.6	2.3	3.24
No. IV	G	Hanover, N. Mex	28 100	30 500	3.5	4.1	4.7
		Cambridge, Mass	27 400	29 700	3.5	3.4	5.15
		New Kensington, Pa	29 300	30 700	4.5	3.3	2.16
		Coco Solo Islands	28 300	29 700	3.5	3.7	4.35
No. IV	S	Hanover, N. Mex	28 200	30 900	3.7	4.0	5.8
		Cambridge, Mass	29 800	30 400	3.5	4.4	5.75
		New Kensington, Pa	28 800	31 700	3.7	3.8	4.87
		Coco Solo Islands	29 400	30 700	3.5	3.7	5.54
No. IV	W	Hanover, N. Mex	30 300	30 800	2.1	2.5	2.2
		Cambridge, Mass	31 200	31 200	1.5	2.2	2.33
		New Kensington, Pa	30 500	31 900	2.6	1.5	1.52
		Coco Solo Islands	32 700	30 800	1.7	1.5	2.18
No. V	C	Hanover, N. Mex	34 200	33 400	1.9	1.5	1.5
		Cambridge, Mass	32 900	34 800	1.1	1.6	1.5
		New Kensington, Pa	31 300	34 200	1.0	1.2	1.22
		Coco Solo Islands	30 600	34 600	1.0	1.2	1.40
No. V	D	Hanover, N. Mex	26 600	27 800	1.4	1.4	1.7
		Cambridge, Mass	30 200	25 700	1.8	1.3	1.66
		New Kensington, Pa	28 100	30 600	1.3	0.7	1.52
		Coco Solo Islands	30 300	27 300	1.0	1.0	1.42
No. V	G	Hanover, N. Mex	27 900	29 300	1.5	1.2	1.5
		Cambridge, Mass	28 100	27 500	1.4	1.4	2.0
		New Kensington, Pa	28 300	30 400	1.5	1.0	1.54
		Coco Solo Islands	28 500	30 000	1.0	1.1	1.77
No. V	S	Hanover, N. Mex	30 600	36 400	2.1	2.0	2.8
		Cambridge, Mass	35 900	37 200	2.1	2.6	3.53
		New Kensington, Pa	35 000	38 500	1.9	2.1	2.86
		Coco Solo Islands	35 900	36 100	2.1	2.1	2.71
No. V	W	Hanover, N. Mex	28 800	27 000	1.5	1.0	0.9
		Cambridge, Mass	31 000	26 500	1.0	0.9	1.22
		New Kensington, Pa	29 800	27 500	0.6	0.5	0.95
		Coco Solo Islands	29 800	28 000	1.0	0.6	0.81
No. VI	C	Hanover, N. Mex	26 100	30 300	3.1	3.6	3.5
		Cambridge, Mass	26 800	30 500	2.6	3.2	3.48
		New Kensington, Pa	29 800	31 700	0.7	3.1	2.41
		Coco Solo Islands	26 400	30 200	2.2	3.4	3.42
No. VI	D	Hanover, N. Mex	25 600	28 700	2.8	3.0	4.1
		Cambridge, Mass	25 200	29 100	2.4	3.1	3.87
		New Kensington, Pa	27 000	31 400	1.1	2.6	2.88
		Coco Solo Islands	27 500	29 300	2.6	2.9	3.88
No. VI	G	Hanover, N. Mex	27 400	30 700	3.4	3.9	5.0
		Cambridge, Mass	29 400	32 200	3.7	4.4	4.71
		New Kensington, Pa	27 800	31 100	3.1	3.0	3.73
		Coco Solo Islands	28 600	30 800	3.2	3.7	4.73

TABLE II.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact, ft-lb.
			Flat Specimen	Round Specimen	Flat Specimen	Round Specimen	
No. VI	S	Hanover, N. Mex	29 200	32 200	3.9	3.9	5.9
		Cambridge, Mass	31 300	32 300	4.2	4.2	6.21
		New Kensington, Pa	30 700	33 300	3.4	4.2	4.93
		Coco Solo Islands	31 000	32 900	4.0	4.2	5.15
No. VI	W	Hanover, N. Mex	32 300	34 900	2.2	2.0	1.9
		Cambridge, Mass	32 400	31 200	1.7	1.6	2.15
		New Kensington, Pa	32 400	32 900	2.1	1.4	1.81
		Coco Solo Islands	30 300	32 800	1.4	1.4	2.20
No. VII	C	Hanover, N. Mex	31 700	35 900	3.0	3.2	3.1
		Cambridge, Mass	32 000	36 400	2.3	3.3	3.01
		New Kensington, Pa	30 500	37 500	1.6	3.1	2.49
		Coco Solo Islands	31 000	36 000	1.9	2.8	2.29
No. VII	D	Hanover, N. Mex	29 700	32 200	1.6	1.8	1.5
		Cambridge, Mass	30 400	32 100	1.2	1.3	1.35
		New Kensington, Pa	26 800	31 500	0.7	1.2	1.42
		Coco Solo Islands	30 800	28 300	1.0	1.1	1.40
No. VII	G	Hanover, N. Mex	27 200	30 500	2.1	2.0	2.6
		Cambridge, Mass	27 400	31 100	1.6	2.2	2.59
		New Kensington, Pa	26 400	31 300	1.5	1.2	2.52
		Coco Solo Islands	26 100	32 200	0.9	2.0	2.59
No. VII	S	Hanover, N. Mex	30 800	34 200	1.5	1.5	1.9
		Cambridge, Mass	33 100	36 100	1.1	1.4	2.04
		New Kensington, Pa	31 700	36 000	1.6	1.0	1.62
		Coco Solo Islands	32 200	36 000	1.0	1.2	1.92
No. VII	W	Hanover, N. Mex	29 800	35 000	1.1	1.0	1.2
		Cambridge, Mass	31 200	33 300	1.2	1.0	1.42
		New Kensington, Pa	29 100	33 000	1.5	0.7	1.17
		Coco Solo Islands	29 100	32 900	0.40	1.1	1.14
No. VIII	C	Hanover, N. Mex	29 900	30 700	5.8	5.7	4.0
		Cambridge, Mass	29 200	30 400	4.8	5.3	4.76
		New Kensington, Pa	28 500	32 800	4.0	6.3	3.33
		Coco Solo Islands	29 100	28 800	4.9	4.4	4.42
No. VIII	D	Hanover, N. Mex	24 900	28 000	2.4	3.3	3.4
		Cambridge, Mass	22 400	28 100	1.7	2.9	3.14
		New Kensington, Pa	25 900	27 400	2.7	2.4	2.76
		Coco Solo Islands	25 100	27 300	2.1	2.6	3.10
No. VIII	G	Hanover, N. Mex	24 800	28 000	3.0	3.5	3.9
		Cambridge, Mass	26 600	27 900	3.2	3.8	3.04
		New Kensington, Pa	26 000	24 200	3.3	2.1	4.54
		Coco Solo Islands	26 500	26 800	3.1	2.9	3.95
No. VIII	S	Hanover, N. Mex	26 500	33 200	3.2	4.8	4.6
		Cambridge, Mass	26 100	34 400	3.0	5.2	5.42
		New Kensington, Pa	26 800	35 000	2.9	5.2	4.31
		Coco Solo Islands	27 900	34 200	3.3	5.2	5.33
No. VIII	W	Hanover, N. Mex	27 200	26 600	5.0	5.6	6.4
		Cambridge, Mass	28 400	38 000	4.6	5.6	6.76
		New Kensington, Pa	28 100	31 000	3.6	5.6	5.42
		Coco Solo Islands	28 800	30 200	4.3	5.3	4.76
No. IX	C	Hanover, N. Mex	29 400	36 500	1.0	1.4	1.5
		Cambridge, Mass	31 600	35 500	1.0	1.4	1.58
		New Kensington, Pa	24 400	36 200	2.2	0.5	1.85
		Coco Solo Islands	30 900	37 600	0.6	1.0	1.10
No. IX	D	Hanover, N. Mex	23 700	28 000	1.3	1.5	1.5
		Cambridge, Mass	25 600	29 700	1.1	1.4	1.46
		New Kensington, Pa	25 000	28 600	2.3	1.0	2.01
		Coco Solo Islands	24 200	28 400	1.0	1.1	1.32
No. IX	G	Hanover, N. Mex	29 300	33 100	1.8	1.8	2.3
		Cambridge, Mass	30 900	33 500	1.7	2.3	2.17
		New Kensington, Pa	28 600	32 700	1.4	1.3	1.76
		Coco Solo Islands	30 000	34 100	1.4	1.6	1.70
No. IX	S	Hanover, N. Mex	28 000	37 500	1.6	2.1	2.2
		Cambridge, Mass	28 800	37 800	1.6	2.2	2.40
		New Kensington, Pa	27 300	37 900	1.1	1.7	1.83
		Coco Solo Islands	27 200	36 600	1.0	1.5	1.98

TABLE II.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact, ft-lb.
			Flat Specimen	Round Specimen	Flat Specimen	Round Specimen	
No. IX	W	Hanover, N. Mex	31 900	38 900	1.5	2.0	1.8
		Cambridge, Mass	33 700	40 100	1.1	1.8	2.23
		New Kensington, Pa	32 900	39 300	1.4	1.3	1.56
		Coco Solo Islands	32 900	38 300	1.0	1.3	1.99
No. X	C	Hanover, N. Mex	30 600	32 500	2.9	3.0	2.6
		Cambridge, Mass	31 300	34 200	2.2	3.2	3.23
		New Kensington, Pa	30 800	34 500	2.4	2.6	2.46
		Coco Solo Islands	30 600	33 500	2.2	2.7	2.75
No. X	D	Hanover, N. Mex	20 200	24 400	1.5	2.5	2.1
		Cambridge, Mass	22 600	25 400	1.8	2.2	2.31
		New Kensington, Pa	20 800	23 200	1.6	1.1	1.57
		Coco Solo Islands	21 200	23 000	1.4	1.6	2.32
No. X	G	Hanover, N. Mex	25 300	27 600	2.3	2.5	2.5
		Cambridge, Mass	24 800	28 400	2.1	2.5	2.75
		New Kensington, Pa	25 200	29 000	2.2	1.9	2.06
		Coco Solo Islands	26 200	27 600	2.1	2.2	2.02
No. X	S	Hanover, N. Mex	26 500	31 400	2.1	2.4	3.2
		Cambridge, Mass	27 300	32 000	1.9	2.9	3.35
		New Kensington, Pa	26 400	32 700	2.2	2.0	2.87
		Coco Solo Islands	27 900	31 300	2.0	2.4	3.14
No. X	W	Hanover, N. Mex	26 500	29 000	2.6	2.7	3.0
		Cambridge, Mass	28 400	30 200	2.2	2.5	2.93
		New Kensington, Pa	26 800	30 200	1.3	1.8	1.85
		Coco Solo Islands	27 400	28 800	2.0	2.2	2.77
No. XI	C	Hanover, N. Mex	32 600	36 600	2.8	3.0	2.8
		Cambridge, Mass	31 800	37 800	2.2	3.0	2.65
		New Kensington, Pa	31 100	37 900	2.1	2.9	2.29
		Coco Solo Islands	32 900	36 700	2.4	2.9	2.52
No. XI	D	Hanover, N. Mex	27 700	27 500	3.0	2.5	3.2
		Cambridge, Mass	29 700	31 300	1.9	2.2	3.06
		New Kensington, Pa	28 300	30 000	1.6	1.4	2.59
		Coco Solo Islands	28 100	30 500	1.6	2.1	2.87
No. XI	G	Hanover, N. Mex	30 200	30 800	2.7	2.2	3.3
		Cambridge, Mass	32 100	32 500	2.7	2.3	3.27
		New Kensington, Pa	30 500	33 000	2.7	2.1	2.70
		Coco Solo Islands	29 400	31 500	1.9	1.9	2.53
No. XI	S	Hanover, N. Mex	28 700	34 200	1.4	1.6	2.3
		Cambridge, Mass	30 200	36 300	1.3	2.0	2.32
		New Kensington, Pa	26 600	34 400	1.7	1.4	2.03
		Coco Solo Islands	29 000	35 500	1.3	1.6	2.03
No. XI	W	Hanover, N. Mex	28 800	31 100	1.3	1.4	1.5
		Cambridge, Mass	30 700	27 500	1.0	0.9	1.28
		New Kensington, Pa	29 300	31 800	1.4	0.7	1.19
		Coco Solo Islands	29 300	30 300	0.7	0.9	1.18
No. XII	C	Hanover, N. Mex	31 200	36 100	2.4	2.8	2.8
		Cambridge, Mass	30 900	37 200	1.9	2.6	2.50
		New Kensington, Pa	31 100	38 000	1.1	2.2	2.13
		Coco Solo Islands	31 900	35 600	1.7	2.2	2.46
No. XII	D	Hanover, N. Mex	28 400	36 400	1.3	1.5	1.9
		Cambridge, Mass	32 400	33 700	1.4	1.0	1.65
		New Kensington, Pa	32 300	35 900	0.5	0.6	1.43
		Coco Solo Islands	32 600	35 200	1.2	1.0	1.53
No. XII	G	Hanover, N. Mex	22 100	32 900	1.5	2.1	3.1
		Cambridge, Mass	24 800	31 700	1.5	2.1	2.71
		New Kensington, Pa	25 400	32 900	1.8	1.2	2.38
		Coco Solo Islands	24 400	34 400	1.0	1.7	2.46
No. XII	S	Hanover, N. Mex	36 100	37 000	2.5	2.7	3.3
		Cambridge, Mass	37 500	37 200	2.2	2.0	3.21
		New Kensington, Pa	37 200	38 800	2.1	1.2	2.50
		Coco Solo Islands	38 000	38 600	2.1	2.1	2.53
No. XII	W	Hanover, N. Mex	33 900	37 200	1.5	1.9	1.7
		Cambridge, Mass	33 700	38 500	1.1	1.3	1.78
		New Kensington, Pa	34 700	34 900	1.2	1.0	1.62
		Coco Solo Islands	34 600	38 300	0.8	1.1	1.47

TABLE III.—PHYSICAL PROPERTIES AND EXPANSION DATA ON ZINC-BASE DIE-CASTING ALLOY SPECIMENS AFTER 1-YEAR OUTDOOR EXPOSURE.

Alloy[a]	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent	Charpy Impact,[b] ft-lb.	Expansion, in.
			Round Specimen[b]	Round Specimen[b]		6-in. Bar
No. XIII	C	Key West, Fla	21 700	1.0	0.65	0.0010
		Sandy Hook, N. J	21 300	0.5	0.64	0.0004
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	21 500	0.5	0.42	0.0000
		New York City	23 300	0.8	0.43	0.0005
No. XIII	D	Key West, Fla	24 200	1.0	0.83	0.0020
		Sandy Hook, N. J	23 500	0.3	0.51	0.0004
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	No Data	No Data	0.54	0.0001
		New York City	25 300	No Data	0.52	−0.0005
No. XIII	R	Key West, Fla	20 000	1.0	0.78	0.0016
		Sandy Hook, N. J	20 600	0.9	0.51	0.0004
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	21 300	1.3	0.60	0.0001
		New York City	22 900	1.6	0.52	0.0001
No. XIII	T	Key West, Fla	21 500	1.5	0.80	0.0028
		Sandy Hook, N. J	20 100	...	0.44	0.0001
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	23 200	1.0	0.55	0.0000
		New York City	25 200	No Data	0.60	0.0002
No. XIV	C	Key West, Fla	33 500	1.0	0.86	0.0148
		Sandy Hook, N. J	36 500	1.0	0.59	0.0053
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	38 600	0.8	0.87	0.0059
		New York City	37 600	1.6	0.69	0.0068
No. XIV	D	Key West, Fla	33 700	1.0	0.84	0.0188
		Sandy Hook, N. J	33 700	0.5	0.51	0.0083
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	41 000	0.6	0.61	0.0071
		New York City	41 400	1.6	0.67	0.0074
No. XIV	R	Key West, Fla	29 900	1.2	0.72	0.0025
		Sandy Hook, N. J	31 200	1.0	0.31	0.0073
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	37 200	0.5	0.55	0.0068
		New York City	34 900	0.8	0.72	0.0063
No. XIV	S	Key West, Fla	37 500	0.5	0.93	0.0113
		Sandy Hook, N. J	37 700	1.0	0.90	0.0041
		Rochester, N. Y	[c]	[c]	[c]	[c]
		Altoona, Pa	41 800	1.1	1.01	0.0042
		New York City	41 800	1.6	1.16	0.0045
No. XIV	T	Key West, Fla	33 800	1.0	0.87	0.0204
		Sandy Hook, N. J	32 500	1.5	0.60	0.0097
		Rochester, N. Y	[c]	[c]	1.80	0.0093
		Altoona, Pa	38 200	2.2	1.21	0.0092
		New York City	45 100	4.7	1.42	0.0079
No. XV	C	Key West, Fla	51 400	2.0	2.11	0.0024
		Sandy Hook, N. J	50 500	2.0	2.85	0.0002
		Rochester, N. Y	55 300	1.8	2.22	0.0009
		Altoona, Pa	50 500	2.8	2.47	0.0002
		New York City	49 400	2.3	2.35	0.0005
No. XV	D	Key West, Fla	48 300	1.0	1.16	0.0035
		Sandy Hook, N. J	44 500	1.0	1.38	0.0016
		Rochester, N. Y	47 700	1.2	2.23	0.0018
		Altoona, Pa	48 800	2.0	1.89	0.0008
		New York City	44 800	1.6	1.92	0.0010

[a] For nominal compositions of alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

[b] For sizes and shapes of tension and impact specimens, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 203 (1928).

[c] Specimens stolen from exposure rack.

TABLE III.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent	Charpy Impact, ft-lb.	Expansion, in.
			Round Specimen	Round Specimen		6-in. Bar
No. XV	R	Key West, Fla	51 800	1.4	2.13	0.0001
		Sandy Hook, N. J	51 100	1.3	3.47	−0.0014
		Rochester, N. Y	53 700	2.9	3.52	−0.0007
		Altoona, Pa	49 800	2.4	3.93	−0.0013
		New York City	47 100	1.3	4.74	−0.0012
No. XV	S	Key West, Fla	43 900	1.4	1.87	0.0034
		Sandy Hook, N. J	45 600	0.5	1.33	0.0011
		Rochester, N. Y	49 800	2.0	3.25	0.0021
		Altoona, Pa	46 200	1.5	2.85	0.0016
		New York City	45 000	1.7	2.83	0.0014
No. XV	Z	Key West, Fla	39 800	1.0	1.11	0.0033
		Sandy Hook, N. J	43 000	0.5	1.31	0.0010
		Rochester, N. Y	48 600	1.8	2.19	0.0017
		Altoona, Pa	45 400	2.6	1.55	0.0016
		New York City	39 000	2.3	2.52	0.0010
No. XVI	C	Key West, Fla	53 500	1.8	1.95	0.0028
		Sandy Hook, N. J	52 300	1.6	2.23	0.0009
		Rochester, N. Y	52 400	1.6	2.15	0.0010
		Altoona, Pa	50 100	1.4	2.57	0.0012
		New York City	51 000	2.1	2.46	0.0004
No. XVI	D	Key West, Fla	46 900	1.0	1.55	0.0030
		Sandy Hook, N. J	46 500	1.0	1.71	0.0010
		Rochester, N. Y	50 900	1.1	2.38	0.0016
		Altoona, Pa	45 500	1.3	1.78	0.0007
		New York City	46 500	1.8	2.70	0.0011
No. XVI	S	Key West, Fla	41 700	1.0	2.06	0.0025
		Sandy Hook, N. J	43 500	1.0	2.46	0.0010
		Rochester, N. Y	49 800	2.1	4.32	0.0011
		Altoona, Pa	44 100	1.2	4.19	0.0007
		New York City	44 000	1.8	3.97	0.0010
No. XVI	Z	Key West, Fla	42 500	2.0	2.41	0.0027
		Sandy Hook, N. J	43 900	1.9	3.61	0.0009
		Rochester, N. Y	46 700	1.9	3.11	0.0017
		Altoona, Pa	43 300	2.2	3.11	0.0013
		New York City	40 400	3.3	3.18	0.0014
No. XVII	D	Key West, Fla	36 300	0.8	0.98	0.0024
		Sandy Hook, N. J	39 300	1.5	0.64	0.0007
		Rochester, N. Y	38 300	0.5	1.38	0.0013
		Altoona, Pa	35 900	0.7	0.88	0.0006
		New York City	33 800	0.8	1.01	0.0008
No. XVII	S	Key West, Fla	38 800	1.0	1.19	0.0029
		Sandy Hook, N. J	40 900	1.0	1.18	0.0010
		Rochester, N. Y	42 000	0.5	1.78	0.0011
		Altoona, Pa	39 900	1.1	1.42	0.0009
		New York City	40 800	1.4	1.38	0.0010
No. XVII	T	Key West, Fla	34 700	0.5	0.97	0.0033
		Sandy Hook, N. J	37 100	...	0.95	0.0016
		Rochester, N. Y	39 200	0.5	1.41	0.0013
		Altoona, Pa	37 400	2.6	1.21	0.0015
		New York City	36 400	2.3	1.11	0.0014
No. XVIII	C	Key West, Fla	20 600	1.3	0.93	0.0042
		Sandy Hook, N. J	21 900	1.5	0.71	0.0019
		Rochester, N. Y	23 500	1.0	1.06	0.0016
		Altoona, Pa	21 900	1.8	0.66	0.0018
		New York City	21 500	1.2	0.60	0.0041
No. XVIII	S	Key West, Fla	14 400	0.5	0.94	0.0080
		Sandy Hook, N. J	16 600	0.5	0.77	0.0047
		Rochester, N. Y	17 300	0.5	1.10	0.0001
		Altoona, Pa	16 500	1.1	0.99	0.0023
		New York City	15 100	0.8	0.90	0.0041

TABLE III.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent	Charpy Impact, ft-lb.	Expansion, in.
			Round Specimen	Round Specimen		6-in. Bar
No. XVIII	T	Key West, Fla	19 600	1.0	0.85	0.0071
		Sandy Hook, N. J	21 100	0.3	0.48	0.0026
		Rochester, N. Y	25 400	0.9	1.22	0.0029
		Altoona, Pa	24 100	2.8	0.79	0.0026
		New York City	37 300	0.8	0.75	0.0026
No. XIX	D	Key West, Fla	39 400	1.3	3.02	0.0010
		Sandy Hook, N. J	38 200	1.6	2.52	0.0000
		Rochester, N. Y	42 400	2.2	6.97	0.0010
		Altoona, Pa	40 700	2.1	5.47	0.0001
		New York City	40 400	2.3	7.02	0.0000
No. XIX	R	Key West, Fla	40 400	1.5	4.71	−0.0009
		Sandy Hook, N. J	39 300	1.0	6.16	−0.0015
		Rochester, N. Y	44 900	2.8	9.43	−0.0010
		Altoona, Pa	41 900	1.5	6.81	−0.0018
		New York City	40 400	1.9	6.88	−0.0017
No. XIX	Z	Key West, Fla	34 900	2.3	3.92	0.0015
		Sandy Hook, N. J	34 600	2.0	4.63	0.0006
		Rochester, N. Y	37 900	3.4	7.20	0.0012
		Altoona, Pa	37 100	2.6	7.43	0.0006
		New York City	34 100	3.1	7.27	0.0001
No. XX	C	Key West, Fla	34 600	1.5	1.02	0.0081
		Sandy Hook, N. J	32 900	0.9	0.64	0.0029
		Rochester, N. Y	36 900	0.7	1.49	0.0044
		Altoona, Pa	34 000	1.5	0.66	0.0056
		New York City	33 700	0.8	0.87	0.0030
No. XX	D	Key West, Fla	37 000	0.7	0.83	0.0208
		Sandy Hook, N. J	31 700	0.5	0.48	0.0078
		Rochester, N. Y	42 700	0.6	1.18	0.0061
		Altoona, Pa	39 500	0.9	0.57	0.0068
		New York City	38 000	0.8	0.52	0.0090
No. XXI	D	Key West, Fla	47 800	1.3	2.84	0.0022
		Sandy Hook, N. J	49 100	2.0	2.82	0.0000
		Rochester, N. Y	51 000	2.2	3.41	0.0015
		Altoona, Pa	46 800	2.6	3.77	0.0002
		New York City	44 900	3.1	4.93	0.0006
No. XXI	R	Key West, Fla	51 200	1.4	2.90	−0.0004
		Sandy Hook, N. J	52 100	1.5	3.73	−0.0011
		Rochester, N. Y	54 300	5.9	4.13	−0.0012
		Altoona, Pa	50 700	1.7	6.39	−0.0019
		New York City	47 600	1.8	5.87	−0.0015
No. XXI	S	Key West, Fla	49 400	2.4	2.88	−0.0011
		Sandy Hook, N. J	47 300	2.7	4.97	−0.0020
		Rochester, N. Y	49 100	3.6	4.53	−0.0012
		Altoona, Pa	44 600	3.0	6.32	−0.0021
		New York City	44 100	2.5	7.00	−0.0023
No. XXI	T	Key West, Fla	45 200	4.0	2.36	0.0021
		Sandy Hook, N. J	47 200	2.3	4.16	0.0009
		Rochester, N. Y	46 600	3.8	4.66	0.0011
		Altoona, Pa	45 700	4.0	4.32	0.0006
		New York City	[a]	1.6	5.19	0.0010
No. XXI	Z	Key West, Fla	42 200	1.5	2.99	0.0010
		Sandy Hook, N. J	46 300	2.5	3.75	−0.0001
		Rochester, N. Y	46 500	5.6	4.20	0.0000
		Altoona, Pa	45 200	3.2	3.36	0.0002
		New York City	43 800	2.9	7.30	−0.0004
No. XXII[c]	C	Key West, Fla	19 300	1.3	0.82	0.0066
		Sandy Hook, N. J	19 000	0.5	0.55	0.0037
		Rochester, N. Y	[b]	[b]	No data	0.0062
		Altoona, Pa	24 500	1.5	0.52	0.0038
		New York City	18 900	0.8	0.52	0.0025

[a] The result reported (22,700) is extremely dubious.

[b] Specimens stolen from exposure rack.

[c] Alloy No. XXII corresponds in composition to alloy No. XVIII except for the use of a higher grade of slab zinc than Prime Western, see Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6), 1930 Book A.S.T.M. Standards, Part I, p. 582.

TABLE IV.—PHYSICAL PROPERTIES AND EXPANSION DATA ON ZINC-BASE DIE-CASTING ALLOY SPECIMENS AFTER 1-YEAR INDOOR EXPOSURE.

Alloy[a]	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact,[b] ft-lb.	Expansion, in.		
			Flat Specimen[b]	Round Specimen[b]	Flat Specimen[b]	Round Specimen[b]		$\frac{3}{4}$-in. Section	$\frac{1}{2}$-in. Section	6-in. Bar
No. XIII...	C..	Coco Solo Islands....	......	......	...	...	....	−0.0004	−0.0001	0.0014
		Hanover, N. Mex....	21 100	22 300	1.1	Nodata	0.5	−0.0004	0.0000	0.0000
		Cambridge, Mass....	21 100	24 200	0.5	0.8	0.53	−0.0004	−0.0002	0.0004
		New Kensington, Pa.	21 900	No data	0.5	Nodata	0.40	−0.0004	−0.0001	0.0006
No. XIII...	D..	Coco Solo Islands....	......	......	...	...	....	−0.0006	0.0000	0.0017
		Hanover, N. Mex....	24 500	26 100	0.9	1.0	0.5	−0.0006	−0.0002	0.0008
		Cambridge, Mass....	25 300	25 900	1.0	0.9	0.57	−0.0007	−0.0001	0.0000
		New Kensington, Pa.	24 500	26 700	0.7	0.5	0.57	−0.0007	−0.0001	0.0005
No. XIII...	R..	Coco Solo Islands....	......	......	...	...	....	−0.0005	0.0000	0.0024
		Hanover, N. Mex....	24 600	24 000	1.1	1.1	0.7	−0.0003	−0.0002	−0.0003
		Cambridge, Mass....	22 700	23 900	0.9	0.6	0.63	−0.0005	−0.0001	−0.0002
		New Kensington, Pa.	23 200	21 600	0.6	0.9	0.52	−0.0005	−0.0001	0.0001
No. XIII...	T..	Coco Solo Islands....	......	......	...	...	....	0.0001	0.0005	0.0056
		Hanover, N. Mex....	26 400	27 900	1.0	1.0	0.7	−0.0001	0.0000	−0.0003
		Cambridge, Mass....	26 800	25 500	0.5	0.9	0.59	−0.0002	−0.0001	0.0003
		New Kensington, Pa.	24 600	23 700	0.5	0.5	0.57	−0.0003	−0.0001	0.0005
No. XIV...	C..	Coco Solo Islands....	......	......	...	...	....	0.0025	0.0018	0.0209
		Hanover, N. Mex....	38 500	41 200	1.5	1.1	0.6	0.0004	0.0005	0.0087
		Cambridge, Mass....	36 900	38 400	0.7	0.8	0.74	0.0006	0.0006	0.0095
		New Kensington, Pa.	37 000	40 800	1.0	0.8	0.78	0.0008	0.0007	0.0083
No. XIV....	D..	Coco Solo Islands....	......	......	...	...	....	0.0020	0.0022	0.0232
		Hanover, N. Mex....	39 500	42 300	1.0	1.1	0.6	0.0000	0.0004	0.0080
		Cambridge, Mass....	39 700	37 200	0.9	0.6	0.66	0.0001	0.0005	0.0097
		New Kensington, Pa.	38 100	41 500	0.9	0.5	0.63	0.0004	0.0006	0.0136
No. XIV....	R..	Coco Solo Islands....	......	......	...	...	....	0.0029	0.0047	0.0383
		Hanover, N. Mex....	34 900	38 600	1.0	1.0	0.6	0.0002	0.0005	0.0093
		Cambridge, Mass....	35 000	35 300	1.0	0.6	0.58	0.0004	0.0007	0.0106
		New Kensington, Pa.	35 200	35 100	0.5	0.5	0.56	0.0009	0.0011	0.0164
No. XIV....	S..	Coco Solo Islands....	......	......	...	...	....	0.0020	0.0022	0.0146
		Hanover, N. Mex....	42 400	42 400	1.5	1.3	1.0	0.0005	0.0005	0.0043
		Cambridge, Mass....	42 700	41 200	1.0	0.9	0.92	0.0006	0.0003	0.0047
		New Kensington, Pa.	41 000	42 800	0.9	0.9	0.73	0.0010	0.0008	0.0084
No. XIV....	T..	Coco Solo Islands....	......	......	...	...	....	0.0037	0.0037	0.0210
		Hanover, N. Mex...	40 200	39 000	1.8	2.5	1.1	0.0005	0.0005	0.0101
		Cambridge, Mass....	37 500	36 600	0.9	1.5	0.88	0.0010	0.0009	0.0110
		New Kensington, Pa.	35 800	37 400	1.3	1.1	0.67	0.0012	0.0011	0.0041
No. XV.....	C..	Coco Solo Islands....	......	......	...	...	....	−0.0007	−0.0001	0.0029
		Hanover, N. Mex....	45 100	49 400	1.4	2.9	2.1	−0.0005	0.0000	0.0015
		Cambridge, Mass....	46 300	51 700	1.1	3.1	2.58	−0.0008	−0.0002	0.0008
		New Kensington, Pa.	43 000	53 900	0.6	2.4	1.76	−0.0006	−0.0002	0.0019
No. XV.....	D..	Coco Solo Islands....	......	......	...	...	....	−0.0003	0.0003	0.0032
		Hanover, N. Mex....	49 200	46 600	1.3	1.6	1.3	−0.0005	0.0000	0.0007
		Cambridge, Mass....	47 500	46 600	1.7	1.7	2.00	−0.0006	−0.0002	0.0010
		New Kensington, Pa.	46 300	47 800	1.2	1.3	1.46	−0.0006	−0.0001	0.0015
No. XV.....	R..	Coco Solo Islands....	......	......	...	...	....	−0.0009	−0.0003	0.0003
		Hanover, N. Mex....	52 300	50 600	1.9	1.4	3.4	−0.0006	−0.0001	−0.0012
		Cambridge, Mass....	51 800	50 300	1.6	1.1	3.46	−0.0007	−0.0002	−0.0013
		New Kensington, Pa.	53 800	51 500	1.2	1.1	2.05	−0.0006	−0.0001	−0.0006
No. XV.....	S..	Coco Solo Islands....	......	......	...	...	....	−0.0001	0.0001	0.0023
		Hanover, N. Mex....	45 900	45 700	2.0	1.7	3.1	−0.0001	0.0000	0.0003
		Cambridge, Mass....	46 600	44 600	1.7	1.6	2.58	−0.0002	−0.0001	0.0006
		New Kensington, Pa.	46 100	48 600	1.4	1.0	1.65	−0.0001	−0.0001	0.0008

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[a] For nominal compositions of alloys, see *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 193 (1929).

[b] For sizes and shapes of tension and impact specimens, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 203 (1928).

TABLE IV.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact, ft-lb.	Expansion, in.		
			Flat Specimen	Round Specimen	Flat Specimen	Round Specimen		$\frac{3}{4}$-in. Section	$\frac{1}{2}$-in. Section	6-in. Bar
No. XV	Z.	Coco Solo Islands	......	......	...	...	....	0.0003	0.0009	0.0041
		Hanover, N. Mex	42 600	42 700	1.3	2.5	1.7	−0.0001	0.0001	0.0010
		Cambridge, Mass	44 500	39 800	0.7	1.2	1.75	−0.0001	0.0001	0.0010
		New Kensington, Pa.	40 500	45 700	0.6	1.5	1.08	0.0000	0.0001	0.0016
No. XVI	C.	Coco Solo Islands	......	......	...	...	....	−0.0008	0.0000	0.0028
		Hanover, N. Mex	47 700	51 500	1.3	1.7	2.1	−0.0007	0.0000	0.0014
		Cambridge, Mass	51 500	52 500	0.6	2.0	2.25	−0.0008	−0.0002	0.0016
		New Kensington, Pa.	49 800	53 700	1.2	1.7	1.30	−0.0008	0.0000	0.0019
No. XVI	D.	Coco Solo Islands	......	......	...	...	....	−0.0005	−0.0001	0.0026
		Hanover, N. Mex	48 300	48 200	1.5	2.0	1.9	−0.0005	−0.0001	0.0009
		Cambridge, Mass	48 500	49 500	1.0	1.5	1.83	−0.0006	−0.0001	0.0006
		New Kensington, Pa.	49 300	51 500	1.0	0.5	1.58	−0.0005	−0.0001	0.0013
No. XVI	S.	Coco Solo Islands	......	......	...	...	....	−0.0001	0.0002	0.0037
		Hanover, N. Mex	45 700	44 800	1.7	1.9	3.8	−0.0002	0.0000	0.0004
		Cambridge, Mass	45 800	44 600	1.3	2.1	3.13	−0.0001	−0.0001	0.0008
		New Kensington, Pa.	43 800	46 000	1.4	1.0	1.89	−0.0001	−0.0001	0.0009
No. XVI	Z.	Coco Solo Islands	......	......	...	...	....	−0.0004	−0.0001	0.0018
		Hanover, N. Mex	42 400	42 800	2.0	2.6	3.8	−0.0003	−0.0001	0.0008
		Cambridge, Mass	44 900	42 500	1.0	2.9	3.41	−0.0003	−0.0001	0.0001
		New Kensington, Pa.	45 200	44 400	1.6	2.2	1.65	−0.0004	0.0000	0.0007
No. XVII	D.	Coco Solo Islands	......	......	...	...	....	−0.0005	0.0000	0.0015
		Hanover, N. Mex	32 700	37 800	1.0	1.0	1.0	−0.0006	−0.0001	0.0004
		Cambridge, Mass	36 100	38 000	0.5	0.0	0.96	−0.0005	−0.0001	0.0005
		New Kensington, Pa.	34 400	39 600	0.5	0.6	0.78	−0.0004	0.0000	0.0007
No. XVII	S.	Coco Solo Islands	......	......	...	...	....	−0.0005	0.0001	0.0023
		Hanover, N. Mex	33 700	41 000	1.0	1.0	1.3	−0.0004	0.0000	0.0004
		Cambridge, Mass	28 200	40 100	0.1	1.1	1.46	−0.0005	−0.0001	0.0011
		New Kensington, Pa.	34 700	40 900	1.0	0.5	1.07	−0.0004	0.0000	0.0013
No. XVII	T.	Coco Solo Islands	......	......	...	...	....	−0.0006	0.0000	0.0024
		Hanover, N. Mex	37 500	39 100	1.0	1.0	1.2	−0.0004	−0.0001	0.0011
		Cambridge, Mass	35 800	40 300	0.6	0.6	1.03	−0.0004	−0.0001	0.0008
		New Kensington, Pa.	34 500	38 200	0.5	0.6	0.79	−0.0005	−0.0001	0.0014
No. XVIII	C.	Coco Solo Islands	......	......	...	...	....	−0.0003	−0.0001	0.0051
		Hanover, N. Mex	19 200	21 900	1.4	1.6	0.6	−0.0004	0.0001	0.0027
		Cambridge, Mass	19 300	21 600	0.7	1.8	0.69	−0.0003	0.0000	0.0023
		New Kensington, Pa.	19 100	23 000	0.7	1.1	0.53	−0.0002	0.0000	0.0042
No. XVIII	S.	Coco Solo Islands	......	......	...	...	....	−0.0002	0.0003	0.0152
		Hanover, N. Mex	17 700	18 800	1.0	1.1	0.9	−0.0001	0.0000	0.0041
		Cambridge, Mass	20 100	16 200	0.6	1.3	1.09	−0.0002	0.0000	0.0047
		New Kensington, Pa.	19 500	18 200	0.6	0.1	0.65	−0.0001	−0.0001	0.0029
No. XVIII	T.	Coco Solo Islands	......	......	...	...	....	0.0008	0.0006	0.0062
		Hanover, N. Mex	14 100	23 500	1.0	1.2	0.9	−0.0002	0.0002	0.0019
		Cambridge, Mass	19 900	19 900	0.5	0.9	0.72	−0.0004	0.0002	0.0014
		New Kensington, Pa.	14 900	23 400	0.5	1.0	0.55	0.0000	0.0004	0.0022
No. XIX	D.	Coco Solo Islands	......	......	...	...	....	−0.0007	−0.0002	0.0007
		Hanover, N. Mex	42 600	41 800	3.3	3.3	6.0	−0.0007	−0.0002	0.0002
		Cambridge, Mass	45 700	41 700	2.1	2.2	6.55	−0.0007	−0.0002	−0.0002
		New Kensington, Pa.	42 600	42 100	2.3	2.8	5.73	−0.0007	−0.0002	−0.0002
No. XIX	R.	Coco Solo Islands	......	......	...	...	....	−0.0009	−0.0003	−0.0006
		Hanover, N. Mex	42 700	42 100	1.6	1.7	6.1	−0.0006	−0.0003	−0.0017
		Cambridge, Mass	43 400	42 000	1.6	2.1	6.10	−0.0009	−0.0001	−0.0015
		New Kensington, Pa.	43 100	41 600	1.7	0.8	4.72	−0.0008	−0.0003	−0.0016
No. XIX	Z.	Coco Solo Islands	......	......	...	...	....	−0.0004	−0.0002	0.0014
		Hanover, N. Mex	36 800	37 100	3.2	3.2	7.8	−0.0003	−0.0001	0.0004
		Cambridge, Mass	37 600	34 800	2.0	2.8	6.64	−0.0004	−0.0001	0.0003
		New Kensington, Pa.	36 600	37 100	2.1	2.6	3.80	−0.0005	−0.0002	0.0005

TABLE IV.—(*Continued.*)

Alloy	Producer	Exposure	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Charpy Impact, ft-lb.	Expansion, in.		
			Flat Specimen	Round Specimen	Flat Specimen	Round Specimen		$\frac{3}{4}$-in. Section	$\frac{1}{2}$-in. Section	6-in. Bar
No. XX....	C..	Coco Solo Islands....	......	......	...	...	....	−0.0003	0.0003	0.0068
		Hanover, N. Mex....	29 800	36 000	1.2	1.0	0.9	−0.0002	0.0001	0.0034
		Cambridge, Mass....	33 100	38 300	0.1	1.3	1.42	−0.0004	0.0000	0.0017
		New Kensington, Pa.	29 000	42 000	0.9	0.5	0.74	−0.0003	0.0001	0.0045
No. XX....	D..	Coco Solo Islands....	......	......	...	...	....	0.0033	0.0025	0.0218
		Hanover, N. Mex....	34 300	40 800	1.0	1.0	0.6	0.0002	0.0005	0.0079
		Cambridge, Mass....	36 500	39 100	0.4	0.7	0.72	0.0002	0.0005	0.0088
		New Kensington, Pa.	35 600	40 200	0.8	1.0	0.53	0.0011	0.0014	0.0043
No. XXI...	D..	Coco Solo Islands....	......	......	...	...	....	−0.0007	0.0000	0.0023
		Hanover, N. Mex....	48 000	49 500	3.0	2.9	4.2	−0.0005	−0.0002	0.0007
		Cambridge, Mass....	49 200	48 300	1.7	1.7	4.24	−0.0006	−0.0001	0.0004
		New Kensington, Pa.	48 700	52 300	1.8	1.4	2.85	−0.0006	−0.0001	0.0014
No. XXI...	R..	Coco Solo Islands....	......	......	...	...	....	−0.0010	−0.0003	0.0002
		Hanover, N. Mex....	53 100	51 200	1.9	2.1	4.3	−0.0007	−0.0001	−0.0016
		Cambridge, Mass....	53 000	50 400	2.2	2.4	4.25	−0.0008	−0.0002	−0.0012
		New Kensington, Pa.	52 100	51 200	2.6	1.2	2.39	−0.0006	−0.0002	−0.0010
No. XXI...	S..	Coco Solo Islands....	......	......	...	...	....	−0.0009	−0.0003	−0.0015
		Hanover, N. Mex....	40 100	47 200	1.2	3.6	7.0	−0.0008	−0.0004	−0.0026
		Cambridge, Mass....	40 900	47 700	0.7	3.3	5.27	−0.0009	−0.0003	−0.0019
		New Kensington, Pa.	41 000	49 100	1.5	2.3	3.82	−0.0008	−0.0002	−0.0021
No. XXI...	T..	Coco Solo Islands....	......	......	...	...	....	−0.0005	−0.0001	0.0026
		Hanover, N. Mex....	47 500	45 400	6.4	4.6	3.7	−0.0003	−0.0001	0.0008
		Cambridge, Mass....	48 900	46 400	4.6	3.1	5.19	−0.0006	−0.0002	0.0004
		New Kensington, Pa.	47 700	48 300	4.0	2.6	2.32	−0.0005	−0.0002	0.0013
No. XXI...	Z..	Coco Solo Islands....	......	......	...	...	....	−0.0003	−0.0002	0.0001
		Hanover, N. Mex....	44 300	46 000	2.9	2.9	4.5	−0.0004	−0.0002	−0.0003
		Cambridge, Mass....	46 600	42 900	1.5	2.7	5.02	−0.0002	−0.0002	−0.0001
		New Kensington, Pa.	48 700	44 800	1.8	2.4	2.91	−0.0003	−0.0002	0.0000
No. XXII[a]..	C..	Coco Solo Islands....	......	......	...	...	....	0.0012	0.0007	0.0117
		Hanover, N. Mex....	15 800	20 500	1.0	1.0	0.6	−0.0002	0.0000	0.0030
		Cambridge, Mass....	17 200	19 800	0.4	0.6	0.62	−0.0002	−0.0001	0.0039
		New Kensington, Pa.	13 400	21 200	0.5	0.8	0.54	0.0002	0.0003	0.0035

[a] Alloy No. XXII corresponds in composition to alloy No. XVIII except for the use of a higher grade of slab zinc than Prime Western, see Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6), 1930 Book of A.S.T.M. Standards, Part I, p. 582.

APPENDIX

THE PHYSICAL PROPERTIES OF ALUMINUM-BASE DIE-CASTING ALLOYS

By A. J. Field[1]

The author has long been interested in the aluminum-base die-casting alloy investigations of Committee B-6 on Die-Cast Metals and Alloys,[2] and in the evaluation of arithmetic averages for the many specimens of the various alloys. At the 1931 annual meeting of the Society D. L. Colwell in a paper on "The Effect of Composition on Aluminum-Base Die-Casting Alloys"[3] gave average values for tensile strength and elongation on round specimens and impact values of aluminum alloys. The author has recently calculated averages using a complete set of reports by laboratories A, B, M, N, U and W as used by Colwell and including tensile strength and elongation on both flat and round specimens, Charpy impact values and Rockwell hardness. The average values in Table I are presented as a compact summary of the data on aluminum-base alloys from the investigations of Committee B-6.

In Table I showing the averages for alloys I to XII, the specimens from each producer are grouped as "acceptable" or "unacceptable" on the basis of chemical analysis. Nominal limits of purity for each alloy in accordance with those established by the committee are also given in Table I. The analyses of the "acceptable" specimens fall within the nominal limits, except in a few cases where they are not more than 0.1 per cent outside the limits, which specimens have been included in order to broaden the basis of the averages as much as possible in view of the limited number of tests available.

In the case of each alloy, the properties of the "acceptable" specimens have been averaged to provide a final set of averages for each alloy.

In regard to the chemical analysis for the specimens of each producer, a revised set of average analyses is included in Table I, these having been evaluated from the reports circulated to the committee. One or two minor differences will be found between the analyses given in Table I and those published in the 1929 Report of Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys.[4] Two individual values were omitted in evaluating these averages, namely, one for copper in alloy No. II (producer C) and one for silicon in alloy No. IV (producer C), as these were rather widely out of line with two other results in each case. In regard to specimens of producer C, a corrected test report by laboratory M was used.

In regard to the Rockwell hardness averages, the results reported by laboratory W were all omitted as they are considerably out of line with others in many cases. Generally speaking, Rockwell hardness tests on die castings are held to be not very reliable as the results may be disproportionately affected by certain factors such as internal unsoundness. As an acceptance test, there-

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[1] The British Aluminum Co., Ltd.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 202 (1928); Vol. 29, Part I, p. 192 (1929); Vol. 30, Part I, p. 318 (1930); and Vol. 31, Part I, p. 261 (1931).

[3] D. L. Colwell, "Effect of Composition on Aluminum-Base Die-Casting Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 268 (1931).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 194 (1929).

Table I.—Analyses of Average Test Values of Aluminum-Base Die-Casting Alloys.

Producer	Chemical Composition, per cent									Physical Properties					
	Copper	Silicon	Nickel	Iron	Manganese	Magnesium	Zinc	Tin	Lead	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Rockwell Hardness, "E" Scale (Red Figures)	Charpy Impact,[c] ft-lb.
										Flat Specimens[a]	Round Specimens[b]	Flat Specimens	Round Specimens		
Alloy No. I, Nominal Composition, 4 per cent Copper															
Nominal[d]....	3.5 to 4.5	1.0	0.5	2.5	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
C..........	4.37	0.47	0	1.48	0.01	0.03	0.05	0	..	22 480	28 590	2.6	5.1	51.5	6.0
D..........	3.51	0.55	0.16	1.50	0.03	0.03	0.18	0	..	24 360	27 500	2.6	4.1	51.6	8.0
S..........	4.23	0.62	0.44	1.90	0.02	0.04	0.03	0	..	25 040	32 940	3.0	4.6	60.4	7.9
W..........	3.80	0.31	0	2.35	0.03	0.0	0.08	0	..	28 980	31 590	4.3	4.0	56.9	5.8
								Average of the above		25 210	30 150	3.1	4.4	55.1	6.9
B. Specimens with unacceptable composition.															
G..........	3.97	0.30	0.02	*2.77*	0.02	0.01	0	0.08	0	26 370	29 580	2.9	2.9	55.1	5.0
Alloy No. II, Nominal Composition, 10 per cent Copper															
Nominal[d]....	9 to 11	1.0	0.5	2.5	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
D..........	8.97	0.35	0.05	1.44	0.07	0.03	0.09	0	..	31 850	34 740	0.8	1.0	85.3	3.1
G..........	9.36	0.29	0	1.71	0.02	0.01	0	0	0	28 680	34 280	2.1	2.5	71.2	3.9
S..........	10.47	0.45	0	1.44	0.01	0.01	0.05	0	..	26 850	35 140	1.4	1.8	80.1	3.6
								Average of the above		29 130	34 720	1.4	1.8	78.9	3.5
B. Specimens with unacceptable composition.															
C..........	*7.13*	0.40	0	1.91	0.01	0.04	0.16	0	..	30 270	34 760	2.9	3.1	73.7	3.8
W..........	8.93	0.44	0	*3.07*	0.03	0	0.20	0	..	34 520	36 720	1.7	1.7	87.3	2.5
Alloy No. III, Nominal Composition, 14 per cent Copper															
Nominal[d]....	13 to 15	1.0	0.5	2.5	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
D..........	13.14	0.33	0.12	1.67	0.08	0.03	0.09	0	..	35 760	39 420	0.5	0.6	92.1	1.4
G..........	14.29	0.26	0	1.72	0.02	0.01	0.03	0	0	33 280	36 450	1.4	1.3	91.2	2.0
S..........	13.20	0.58	0	1.58	0.01	0.01	0.08	0	..	32 600	40 400	1.0	1.0	93.5	2.3
								Average of the above		33 880	38 760	1.0	1.0	92.3	1.9
B. Specimens with unacceptable composition.															
C..........	*11.99*	0.43	0	1.89	0.02	0.03	0.09	0	..	34 400	37 500	1.2	1.5	88.3	2.8
W..........	13.02	0.37	0	*2.74*	0.03	0.02	0.11	0	..	36 320	38 830	1.0	1.0	95.8	1.6
Alloy No. IV, Nominal Composition, 5 per cent Silicon															
Nominal[d]....	0.6	4.5 to 6	0.5	2.0	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
D..........	0.45	5.07	0	1.47	0.06	0.07	0.44	0	..	24 580	25 890	2.5	2.3	57.6	4.7
G..........	0.49	5.27	0	1.29	0.02	0.01	0	0	0	27 290	29 810	3.4	3.6	58.7	5.4
S..........	0.30	5.11	0.22	1.89	0.04	0.01	0.11	0	..	28 050	30 570	3.0	3.4	66.4	6.2
								Average of the above		26 640	28 760	3.0	3.1	60.9	5.4
B. Specimens with unacceptable composition.															
C..........	0.58	*3.67*	0.01	1.85	0.01	0.07	0.02	0	..	29 150	30 020	3.9	4.4	58.0	5.0
W..........	0.61	4.41	0	*2.53*	0.03	0.02	*5.90*	0	..	30 050	29 970	2.2	2.0	75.2	2.4

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[a] Flat specimens were $\frac{1}{2}$ by $\frac{1}{8}$-in. tensile strength specimens 9 in. in length.

[b] Round specimens were $\frac{1}{4}$-in. diameter tensile strength specimens 9 in. in length.

[c] Impact specimens were $\frac{1}{4}$-in. square bars 6 in. in length.

[d] Values shown opposite "Nominal" are range or maximum shown in Tentative Specifications for Aluminum-Base Alloy Die Castings (A.S.T.M. Designation: B 85 - 31 T), with comparable values shown for alloys not included in the specifications, see *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 716 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 292.

[e] Total other impurities, including lead.

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TABLE I.—(*Continued.*)

Producer	Chemical Composition, per cent									Physical Properties					
	Copper	Silicon	Nickel	Iron	Manganese	Magnesium	Zinc	Tin	Lead	Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Rockwell Hardness, "E" Scale (Red Figures)	Charpy Impact,[c] ft-lb.
										Flat Specimens[a]	Round Specimens[b]	Flat Specimens	Round Specimens		
ALLOY NO. V, NOMINAL COMPOSITION, 12 PER CENT SILICON															
Nominal[d]....	0.6	11 to 13	0.5	2.0	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
C..........	0.64	13.00	0.06	1.59	0.19	0.09	0.22	0	..	33 420	33 570	1.4	1.5	85.7	1.8
G..........	0.16	12.43	0	1.89	0.02	0.01	0.03	0.06	0.21	27 940	28 300	1.0	1.1	80.0	1.6
S..........	0.06	12.97	0.02	1.35	0.02	0.03	0.06	0	..	34 860	35 820	1.7	2.0	83.0	3.6
								Average of the above		32 070	32 560	1.4	1.5	82.9	2.3
B. Specimens with unacceptable composition.															
D..........	*1.21*	11.96	0.03	1.51	0.09	0.12	*0.90*	0	..	27 180	27 430	0.9	1.0	78.6	2.2
W..........	0.20	*10.72*	0	*4.34*	0.06	0.04	0.60	0	..	29 720	29 050	0.8	0.8	89.6	1.2
ALLOY NO. VI, NOMINAL COMPOSITION, 2 PER CENT COPPER, 3 PER CENT SILICON															
Nominal[d]....	1.5 to 2.5	2.5 to 3.5	0.5	2.5	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
D..........	1.98	3.19	0	1.53	0.05	0.03	0.31	0	..	25 100	27 960	2.2	3.0	58.4	4.8
G..........	2.06	3.23	0	1.88	0.03	0.01	0.01	0	0	26 470	29 910	3.3	4.0	57.5	5.6
S..........	2.18	3.27	0	1.86	0.02	0.02	0.04	0	..	29 990	31 220	3.9	3.8	67.5	6.1
								Average of the above		27 190	29 700	3.1	3.6	61.1	5.5
B. Specimens with unacceptable composition.															
C..........	1.91	2.96	0.37	1.30	*0.66*	0.05	0.42	0	..	26 100	29 600	2.5	3.4	65.0	4.2
W..........	2.16	*5.01*	0	*3.38*	0.06	0.01	0.16	0	..	31 430	32 530	1.6	1.7	80.3	2.1
ALLOY NO. VII, NOMINAL COMPOSITION, 4 PER CENT COPPER, 5 PER CENT SILICON															
Nominal[d]....	3.5 to 4.5	4.5 to 5.5	0.5	2.25	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
C..........	3.53	5.11	0.06	1.45	0.29	0.01	0.43	0	..	29 870	34 980	2.2	3.3	72.9	3.9
D..........	3.86	5.18	0.05	1.51	0.05	0.04	0.38	0	..	28 030	30 220	1.2	1.2	79.0	2.0
S..........	3.78	5.08	0.12	1.86	0.02	0.01	0.12	0	..	30 420	34 170	1.2	1.2	86.2	2.3
								Average of the above		29 440	33 120	1.5	1.9	79.4	2.7
B. Specimens with unacceptable composition.															
G..........	3.92	4.83	0	1.56	0.10	0.01	0.08	*0.76*	*0.48*	26 680	30 230	1.8	2.0	70.7	2.8
W..........	3.53	*5.70*	0	*3.07*	0.05	0	0.22	0	..	28 910	31 930	0.8	1.2	87.1	1.6
ALLOY NO. VIII, NOMINAL COMPOSITION, 1.5 PER CENT COPPER, 1 PER CENT SILICON, 2.25 PER CENT NICKEL															
Nominal[d]....	1 to 2	0.75 to 2	1.75 to 2.5	2.5	0.3	0.1	0.75	0.1	0.2[e]						
A. Specimens with acceptable composition.															
D..........	1.90	0.84	2.22	1.70	0.04	0.04	0.10	0	..	24 010	26 040	2.1	2.7	55.2	3.2
G..........	1.63	1.43	1.84	1.58	0.10	0.01	0	0	0	26 300	27 870	3.1	3.2	53.0	4.2
S..........	1.85	0.95	2.38	1.63	0.06	0.03	0.05	0	..	26 250	33 300	3.1	5.1	61.9	5.6
								Average of the above		25 520	29 070	2.8	3.7	56.7	4.3
B. Specimens with unacceptable composition.															
C..........	1.54	*0.46*	*1.50*	1.67	0.02	0.01	0.03	0	..	28 570	31 310	4.5	6.3	61.8	5.6
W..........	*0.45*	2.06	*0.90*	*3.52*	0.08	0.01	0.07	0	..	28 270	30 470	4.0	4.5	55.5	7.3

[a] Flat specimens were $\frac{1}{2}$ by $\frac{1}{8}$-in. tensile strength specimens 9 in. in length.

[b] Round specimens were $\frac{1}{4}$-in. diameter tensile strength specimens 9 in. in length.

[c] Impact specimens were $\frac{1}{4}$-in. square bars 6 in. in length.

[d] Values shown opposite "Nominal" are range or maximum shown in Tentative Specifications for Aluminum-Base Alloy Die Castings (A.S.T.M. Designation: B 85 - 31 T), with comparable values shown for alloys not included in the specifications, see *Proceedings*, Am Soc. Testing Mats., Vol. 31, Part I, p. 716 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 292.

[e] Total other impurities, including lead.

TABLE I.—(*Continued.*)

Producer	Chemical Composition, per cent									Physical Properties					
										Tensile Strength, lb. per sq. in.		Elongation in 2 in., per cent		Rockwell Hardness, "E" Scale (Red Figures)	Charpy Impact,[c] ft-lb.
	Copper	Silicon	Nickel	Iron	Manganese	Magnesium	Zinc	Tin	Lead	Flat Specimens[a]	Round Specimens[b]	Flat Specimens	Round Specimens		
ALLOY No. IX, NOMINAL COMPOSITION, 4 PER CENT COPPER, 1.75 PER CENT SILICON, 4 PER CENT NICKEL															
Nominal[e]....	3.5 to 4.5	1 to 2.5	3.5 to 4.5	2.5	0.3	0.1	0.75	0.1	0.2[f]						
A. Specimens with acceptable composition.															
D..........	3.86	1.64	3.78	1.15	0.04	0.04	0.23	0	..	24 840	27 840	0.1	1.2	74.4	1.7
G..........	4.07	1.46	3.68	1.41	0.02	0.01	0	0	0	27 620	30 980	1.7	1.7	71.9	2.6
S..........	4.18	1.55	3.83	1.68	0.06	0.02	0.12	0	..	25 830	35 850	1.2	2.3	79.4	2.7
								Average of the above		26 300	31 560	1.0	1.7	75.2	2.3
B. Specimens with unacceptable composition.															
C..........	4.12	2.30	4.31	1.19	*0.63*	0.01	0.28	0	..	30 150	31 600	1.1	1.0	84.9	1.9
W..........	*3.28*	*3.58*	*1.06*	*4.97*	0.08	0.01	0.18	0	..	31 470	36 840	1.4	1.7	84.7	2.4
ALLOY No. X, NOMINAL COMPOSITION, 2 PER CENT SILICON, 5 PER CENT NICKEL															
Nominal[e]....	0.6	1.5 to 2.5	4.5 to 5.5	2.5	0.3	0.1	0.75	0.1	0.2[f]						
A. Specimens with acceptable composition.															
D..........	0.24	2.30	4.54	1.00	0.05	0.04	0.27	0	..	21 410	24 060	1.4	1.7	58.5	2.3
G..........	0.41	1.93	4.61	1.47	0.02	0.01	0.08	0	0	25 340	27 930	2.2	2.3	60.2	2.7
S..........	0.35	2.03	4.83	1.63	0.07	0.04	0.13	0	..	27 260	31 610	1.9	2.2	72.4	3.7
								Average of the above		24 670	270 87	1.8	2.1	63.7	2.9
B. Specimens with unacceptable composition.															
C..........	0.44	2.06	4.39	1.05	*0.73*	0:09	0.09	0	..	29 600	32 640	2.4	2.8	73.0	3.5
W..........	*0.76*	1.78	4.29	1.88	0.06	0.01	0.24	0	..	27 260	29 600	2.1	2.3	67.2	3.0
ALLOY No. XI, NOMINAL COMPOSITION, 2 PER CENT COPPER, 8 PER CENT SILICON															
Nominal[e]....	1.5 to 2.5	7 to 9	0.5	2.5	0.3	0.1	0.75	0.1	0.2[f]						
A. Specimens with acceptable composition.															
G..........	2.09	7.65	0	0.90	0.02	0.03	0.06	0.15	0	30 640	30 840	2.3	2.2	73.8	3.4
S..........	2.07	7.30	0.19	1.92	0.02	0.04	0.08	0	..	28 000	33 810	1.2	1.2	80.6	2.7
								Average of the above		29 320	32 320	1.7	1.7	77.2	3.0
B. Specimens with unacceptable composition.															
C..........	2.00	7.48	*0.80*	0.99	*0.70*	0.02	0.10	0	..	30 920	36 460	2.2	3.1	75.6	3.7
D..........	*0.33*	7.95	0	1.40	0.04	0.04	0.51	0	..	27 920	29 450	1.4	1.9	71.4	3.8
W..........	1.46	*6.86*	0.37	*2.91*	0.04	0.01	0.36	0	..	29 350	29 810	1.0	1.0	82.8	1.5
ALLOY No. XII, NOMINAL COMPOSITION, 8 PER CENT COPPER, 1.5 PER CENT SILICON															
Nominal[e]....	7 to 9	1 to 2	0.5	2.5	0.3	0.1	1.0	0.2	0.5[f]						
A. Specimens with acceptable composition.															
D..........	7.86	1.19	0.04	1.60	0.10	0.02	0.14	0	..	30 090	33 790	1.0	0.9	83.7	2.0
S..........	7.55	1.48	0	1.97	0.01	0.03	0.09	0	..	34 080	35 040	2.4	2.3	81.6	4.4
								Average of the above		32 080	34 410	1.7	1.6	82.6	3.2
B. Specimens with unacceptable composition.															
C..........	7.62	*0.72*	0.11	1.74	0.01	0.02	0.04	0	..	29 750	33 830	2.3	2.7	73.1	3.8
G..........	7.90	1.17	0	1.00	0.02	0.03	0.07	*0.40*	0	25 430	29 870	1.7	2.1	68.5	3.5
W..........	*6.83*	*3.08*	0.03	2.57	0.05	0.01	0.12	0	..	33280[d]	35 240	1.4	1.4	86.0	2.1

[a] Flat specimens were ½ by ⅛-in. tensile strength specimens 9 in. in length.

[b] Round specimens were ¼-in. diameter tensile strength specimens 9 in. in length.

[c] Impact specimens were ¼-in. square bars 6 in. in length.

[d] Excluding laboratory W.

[e] Values shown opposite "Nominal" are range or maximum shown in Tentative Specifications for Aluminum-Base Alloy Die Castings (A.S.T.M. Designation: B 85 – 31 T), with comparable values shown for alloys not included in the specifications, see *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 716 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 292.

[f] Total other impurities, including lead.

fore, Rockwell hardness could perhaps not be countenanced. But in the present case the averages given are those of a large number of tests and it was felt that they could be usefully included as a reasonably reliable arbitrary measure of that important factor, the intrinsic hardness of each alloy.

From a study of the final averages of the acceptable specimens of each alloy, the following facts may be commented on:

1. For a given alloy, the average physical properties of specimens from different producers in some cases differ to a considerable extent, though of acceptable composition. It does not appear that the small variations of analysis will account for the comparatively wide differences in physical properties. It is, therefore, to be inferred that the differences of properties must have been due to variations in production practice. Variables of the die-casting process other than chemical composition, such as metal and die temperatures, gating, type of machine, etc., which were not recorded, must be held to be the cause of such variations of properties in the acceptable specimens of the same alloys.

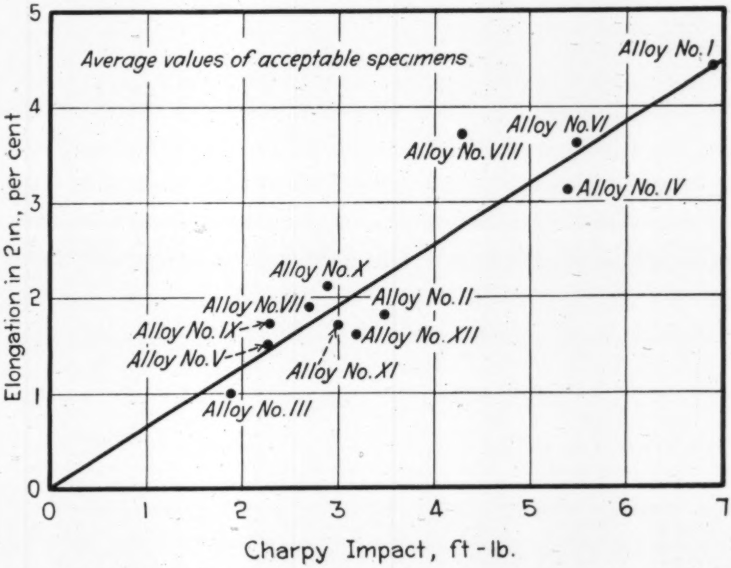

FIG. 1.—Relation Between Elongation and Impact Strength of Aluminum Alloys.

2. Comparing the average results of flat and round tension test specimens, it can be seen that the flat specimens show a consistently lower tensile strength than the round. These differences are in the reverse direction from what would be expected as a result of differences in chilling. The most probable cause of the differences would appear to lie in the greater internal soundness of the gage lengths of the round test specimens, which may perhaps be due to the better feeding of the gage lengths of the round test specimens from the thicker ends either by pressure or capillarity. This supposed greater soundness of the round specimens is confirmed by the Dix and Keller photomacrographs.[1] The results for flat and round specimens differ least in the case of high silicon binary alloy No. V, which testifies to the specially good casting qualities of this alloy.

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[1] E. H. Dix, Jr. and J. F. Keller, "Microscopic Analysis of Specimens of Die-Cast Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 215 (1929).

3. Owing to the greater soundness of the round specimens, it seems that the tensile strengths for these represent the intrinsic properties of the alloys more nearly than the results for the flat specimens. On the other hand, it is perhaps possible that the results for the flat test specimens represent more closely the strength of actual die castings as the general dimensions of the flat specimens give a closer representation of conditions likely to be found in practice.

4. Minimum individual results of tensile strength were reported by each laboratory. These in many cases are of the order of 5000 lb. per sq. in. below the final average for the alloy and in some cases lower. This divergence would need to be taken into consideration in using the average tensile properties for design purposes.

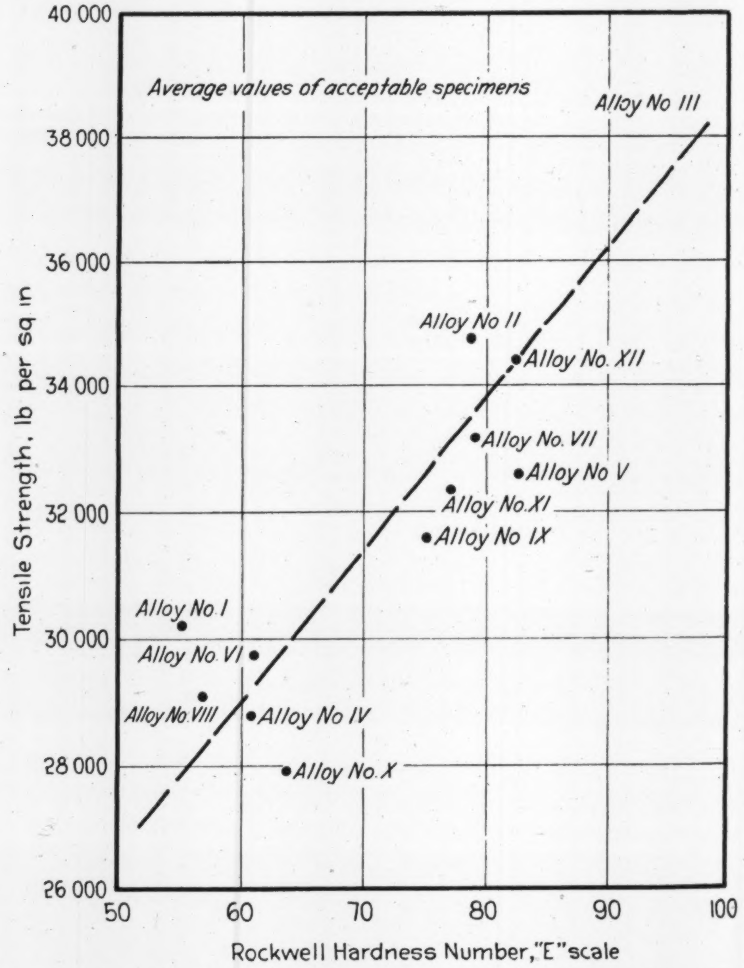

FIG. 2.—Relation Between Tensile Strength and Hardness of Aluminum Alloys.

5. Regarding correlation between physical properties, Figs. 1, 2 and 3 have been plotted using the average values of "acceptable" specimens for each alloy.

In Fig. 1 in which Charpy impact values on ¼-in. square specimens have been plotted against elongation on ¼-in. round specimens, a fairly close linear relation is seen to hold (except for alloy No. VIII) confirming that elongation is a fair measure of toughness for this series of alloys. This statement should not be applied to the comparison of alloys of this series with those of other types.

In Fig. 2 the tensile strengths on ¼-in. round specimens have been plotted against Rockwell hardness. As would be expected there is a rough direct relationship but the points are too widely scattered to justify the drawing of a curve of relationship. The broken curve has been inserted as indicating the general direction of the relationship. The binary copper alloys Nos. I, II and III have a rather higher tensile strength for a given hardness than the others.

Figure 3 shows Charpy impact values plotted against Rockwell hardness. It can be seen that there is a fairly well defined inverse relationship for most of the alloys, which lie close to the hyperbolic curve which has been superimposed. As this is a downwardly displaced hyperbola, it must be noted that all points on it do not have the same product of the two properties, but that the alloys with greater impact value are the better in this theoretical respect. A point of interest is that alloys located below the curve have an inferior product of properties compared with alloys located on the curve in their vicinity. In this way it can be seen that alloys Nos. VIII, IX and X have an inferior combination of the two properties, and it is of interest to note that these three are the only alloys containing added nickel. Colwell[1] has also drawn attention to the rather inferior combinations of properties of alloys Nos. VIII and IX.

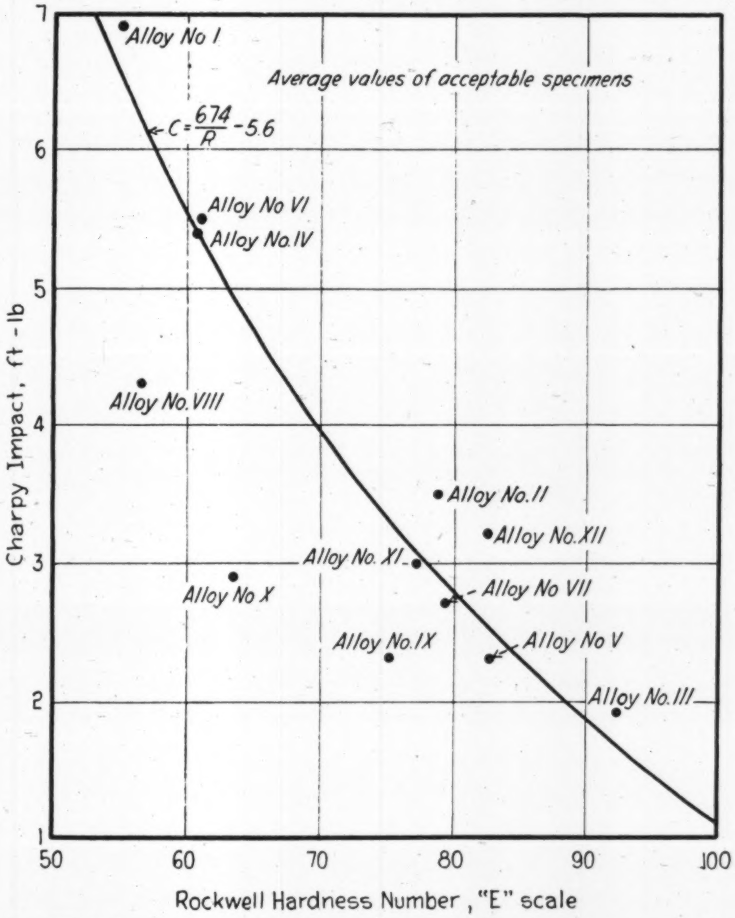

FIG. 3.—Relation Between Impact Strength and Hardness of Aluminum Alloys.

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[1] *Loc. cit.*

REPORT OF COMMITTEE B-7

ON

LIGHT METALS AND ALLOYS, CAST AND WROUGHT

Committee B-7 has held one meeting since the publication of the last annual report, namely, in Cleveland, Ohio, on March 10, 1932. Two new members have been gained and two lost, leaving a total committee membership of 33 classified as follows: 15 Consumers, 5 General Interests and 13 Producers.

Committee B-7 in its 1931 annual report submitted three new proposed tentative specifications covering light metals. Since the specifications covered metals which involved patents they were accordingly referred to the Executive Committee and their submission for publication as tentative was contingent upon the approval of that committee. The Executive Committee has now obtained the necessary assurance that the adoption of these specifications by the Society confers a definite benefit to the consumer in defining qualities and tests to which the patented material must conform and also, that the conditions under which the patented material is marketed are equitable and generally satisfactory to industry. The committee accordingly submits for publication as tentative, as appended hereto,[1] these three specifications which are as follows:

Proposed Tentative Specifications for Aluminum-Copper-Magnesium-Manganese Alloy Bars, Rods and Shapes, prepared by Subcommittee III on Aluminum and Aluminum Alloys, Wrought Shapes Other than Sheet (P. V. Faragher, chairman);

Proposed Tentative Specifications for Magnesium-Base Alloy Sheet, prepared by Subcommittee V on Magnesium and Magnesium-Base Alloys, Cast and Wrought (J. A. Gann, chairman);

Proposed Tentative Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet), prepared by Subcommittee V on Magnesium and Magnesium-Base Alloys, Cast and Wrought (J. A. Gann, chairman).

Subcommittee VI on Methods of Testing Light Alloys (R. L. Templin, chairman).—This new subcommittee has been created to study methods of testing light alloys, specifically the determination of their elastic properties. The subcommittee is fully organized and expects to be active during the coming year.

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[1] See pp. 687 to 694.—Ed.

Subcommittee VII on Service Characteristics of Light Metals (E. H. Dix, Jr., chairman).—This new subcommittee has been formed to meet the demand of the engineering profession for reliable information on the service characteristics of light metals and alloys. It has been charged with the task of collecting, correlating, evaluating, and disseminating data on physical properties and corrosion resistance of aluminum and magnesium alloys. A comprehensive program is now under way indicating that this subcommittee will be very active during the coming year.

Subcommittee VIII on Test Bar Design for Light Metals (W. M. Weil, chairman).—Subcommittee VIII will undertake the study of the proper design of test bars for use with light metals.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Specifications for Aluminum-Copper-Magnesium-Manganese Alloy Bars, Rods and Shapes	20	0	3
Specifications for Magnesium-Base Alloy Sheet	14	0	3
Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet)	14	0	3

This report has been submitted to letter ballot of the committee, which consists of 33 members; 19 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. B. JOHNSON,
Chairman.

J. A. GANN,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Magnesium-Base Alloy Sheet and for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) were accepted for publication as tentative and appear on pages 691 and 693, respectively.

The proposed Tentative Specifications for Aluminum Alloy Wire, Rods and Bars as revised on the floor of the annual meeting, see Summary of Proceedings, page 29, were accepted for publication as tentative. The revised specifications entitled Tentative Specifications for Aluminum-Copper-Magnesium-Manganese Alloy Bars, Rods and Shapes appear on page 687.

REPORT OF COMMITTEE C-1
ON
CEMENT

Committee C-1 on Cement has made most gratifying progress during the year although it held but one meeting. This meeting was unusually well attended and the progress made confirmed the fact that some of the subcommittees and certain sections had been very active in the problems assigned to them.

As a result of the year's activities, the committee is presenting a revision of the Standard Methods of Testing Cement (C 77 - 30); a revision of the Manual of Cement Testing; and is recommending the withdrawal of the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 - 16 T). There is also included in this report a summary of the activities of the committee's paid technical assistant; a report covering a study of all tests known to it on the effects of the use of hot cement in making concrete; and a report covering the activities, which the committee is partially financing, of the Cement Reference Laboratory at the U. S. Bureau of Standards.

Subcommittee D on Masonry Cement, entrusted with the preparation of a standard for masonry cement, has prepared proposed Tentative Specifications and Tests for Masonry Cement which the committee approved for submission to the Society through Committee E-10 on Standards for publication as tentative.[1] The specifications were approved by Committee E-10 on April 8, 1932, and assigned the A.S.T.M. Designation C 91 - 32 T. The interest in this type of cement is very keen. The number of producers and the amount of such cement made is increasing very rapidly; there appear to be somewhat more than forty mills now making this commodity.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Standard Methods of Testing Cement (C 77 - 30).[2]—One of the products of the activities of the Cement Reference Laboratory has been the compilation and digest of the observations made throughout the country, by its inspectors, of cement testing equipment. Through them the Laboratory has been able to obtain a better understanding of the tolerances which should apply to the dimensions of the testing apparatus. It has found that in some cases those now in effect should be changed. It has also realized that the wording used in the present standard is subject to several interpretations which, of necessity, is most undesirable. The committee has, therefore, completely revised Methods C 77, as appended hereto,[1] and recommends their immediate adoption as standard to supersede the present methods. The committee accordingly asks for the necessary nine-tenths vote at the annual meeting in order that the revised methods may be submitted to letter ballot vote of the Society.

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[1] In submitting the specifications to Committee E-10 on Standards, the committee reported the results of the letter ballot vote as follows: 59 members returned their ballots of whom 55 voted affirmatively, 2 negatively, and 2 refrained from voting.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 30.

The inspectors of the Cement Reference Laboratory have found in their discussions with the staffs at many laboratories that the Manual of Cement Testing[2] which supplements the Standard Methods of Testing Cement (C 77) should be made far more explicit, less subject to ambiguous meanings and in some places be far more detailed. Consequently the committee has largely rewritten the Manual, as appended hereto, in accordance with the changes made in the methods of testing. It should be mentioned that while there are still many interested in cement testing who could profit by a study of the Manual, in general it is very widely used and is universally considered essential as an instructive text for cement testers.

Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 - 16 T).[3]—Previous to this time the committee has not felt it would be desirable to withdraw or advance to standard these tentative specifications and tests although they were first issued as tentative in 1916. The committee has now, however, decided to ask their withdrawal. When these specifications and tests were first published as tentative it was believed that the test specimens should more properly be cylindrical in form. It seems, however, that such a small cylinder as indicated is quite difficult to make and prepare as a test specimen. It is also undesirable to indicate a larger one, since such a procedure would necessitate the use of too much standard sand. While it now appears that a cube would be a more desirable test specimen, the committee does not feel that the use of the now prescribed stiff mortar is satisfactory. Consequently, pending the completion of studies now under way of the use of plastic mortars, the committee recommends the withdrawal of the Tentative Standard C 9 - 16 T.

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 161 (1925).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1931 Book of A.S.T.M. Tentative Standards, p. 220.

The recommendations in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. REVISION OF STANDARD			
Standard Methods of Testing Cement (C 77 - 30), immediate adoption	61	2	4
II. WITHDRAWAL OF TENTATIVE STANDARD			
Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 - 16 T)[a]	54	7	6

[a] The classified vote on the withdrawal of the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars was as follows: Affirmative: 24 producers, 17 consumers, 13 general interests; negative: 4 producers, 1 consumer, 2 general interests; not voting: 4 producers, 1 consumer, 1 general interest.

COMMITTEE ACTIVITIES

Mr. J. R. Dwyer, the Technical Assistant of the committee, has been making contacts with those who he has learned have promulgated standards differing from those of the Society. This procedure, it is believed, is being productive of excellent results. The public is being acquainted with the earnest desire of the committee to learn of those conditions which it is believed demand requirements not in the A.S.T.M. standard. The public is learning also of the committee's desire to cooperate in the exchange of data regarding all phases of studies which have led to the adoption of the standards by both parties. It seems that there is not in general any great amount of major departures. It appears rather that certain special conditions are believed by some to exist in such special cases which suggest slight changes in the values of the Society's requirements or a certain additional feature or features not covered by the Society's standards. Invariably the latter is used as a model. In a general way, Mr. Dwyer has continued to direct the activities of the Cement Reference Laboratory. He has also been engaged in calling the attention of the subcommittees and sections to the facts he has been accumulating in his contacts, and is keeping these groups informed of each other's progress.

Subcommittee B on Specifications for Portland Cement (W. H. Klein, chairman).—The effect of the use of hot cement in making concrete, especially for highway work, has been a matter of concern to many and has resulted in there being promulgated a number of specifications which put an upper limit on the temperature of the cement which will be accepted. This frequently results in extra costs, since the producer must either cool the cement after grinding and before storage, or procure more storage facilities where the slowly cooling cement can acquire the accepted temperature. This condition became so acute that Section IV on Effect of Temperatures of Cement at Time of Use, under the chairmanship of Mr. O. L. Moore, has made this a matter of special study and has prepared the appended report. This is largely a digest of what data and reports the committee could find, with some results which were obtained through its cooperation, and some conclusions which it felt the data indicated. These data, it is believed, should be of value to those who are interested in this matter. The several reports seem to present two opposite viewpoints and general conclusions, all of which would seem to emphasize the need for those interested in the purchase of cement to study all conditions, besides hot cement, which tend to produce hot concrete.

Subcommittee on Cement Reference Laboratory (F. W. Kelley, chairman).—There is but slight need to call attention to the continued success of the Cement Reference Laboratory. The report of the subcommittee, appended hereto, speaks sufficiently for itself. Possibly no better estimate of its work could be cited than the ruling of the U. S. Bureau of Public Roads to the effect that reports of acceptance tests of cement for Federal Aid Roads will be accepted only from laboratories which have been surveyed by a representative of the Cement Reference Laboratory to determine whether those laboratories are so adequately equipped and operated as to meet the requirements of the Society's standards for cement.

The election of officers resulted in the reelection of the present incumbents and the selection of Mr. Geoff A. Saeger as secretary, all for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 71 members; 68 members returned their ballots, of whom 63 have voted affirmatively and 2 negatively.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

J. R. Dwyer,
Acting Secretary.

EDITORIAL NOTE

The proposed immediate revision of the Standard Methods of Testing Cement was approved at the annual meeting by a unanimous vote and subsequently adopted by letter ballot of the Society on September 1, 1932. The revised methods entitled "Methods of Sampling and Testing Portland Cement" appear in the 1932 Supplement to Book of A.S.T.M. Standards, page 23.

The withdrawal of the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars was approved.

REPORT OF SECTION IV ON EFFECT OF TEMPERATURES OF CEMENT AT TIME OF USE

The question of whether the temperature of cement at the time of use affects the properties of the resulting concrete has been raised, chiefly by highway engineers, and several highway departments have instituted requirements limiting the temperature of cement. The efforts of the section have been: (1) to study the results of all published investigations bearing on the subject, (2) to obtain and study the data and experiences of those engineers who limit cement temperature at time of use, and (3) to encourage further investigations and to obtain and study these results. The committee has been reasonably successful in these efforts and has prepared digests of the material obtained. These digests, which are appended to this report, are listed in the order in which they were received by the section.

Sources of Heat in Cement.—The section believes that the source of heat in cement is so generally understood today that no data need be cited on the point. However, it should be stated that the heat developed in grinding cement raises its temperature materially; that the heat dissipates slowly because of the nature of the material and that it is not generated in the dry powder by any chemical action.

Discussion of Test Data

Finishing, Checking and Cracking of Slabs.—The field results of Davey(**2**),[1] Miesenhelder(**14**) and Ferguson(**16**) are in agreement (*a*) that no difficulties were encountered in finishing the various slabs in which cement of different temperatures was used, and (*b*) that no differences in checking and cracking were observed. Litehiser(**15**) feels justified in concluding from his laboratory investigations to date that cement of 190° F. does not promote checking or cracking where curing is immediate and thorough. Miesenhelder reports that during the placing of one section (No. 3, cement 80° F.), the finishers complained that the set was occurring more rapidly, concrete was sticky and water was not coming to the surface. The difficulty was not encountered in the next section (No. 4, cement 167° F.) and he suggests weather conditions as the probable cause. Volume change measurements in the Miesenhelder test, using a 20-in. gage length and a Whittemore strain gage, show considerable variation as might be expected but no distinction is justified between the low- and high-temperature cement concrete.

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[1] **The boldface numbers in parentheses refer to the reports and papers given in the list of references appended to this report, see page 302.**

Strength of Concrete, Field Tests.—The results of field cylinders in the Miesenhelder(14) and Ferguson(16) investigations are in accord in that the compressive strengths are not affected by cement temperatures. The beam results are similar except that at 7 days the Miesenhelder test and one of the four Ferguson tests are about 10 per cent lower in the case of the higher cement temperatures. At 28 days the Ferguson results are practically equal. At 14 days the Miesenhelder results are 4 per cent higher for the high temperature cement concrete, at 28 days 5.5 per cent lower, and at three months 2.5 per cent lower. These results are within limits of experimental error.

Strength of Concrete, Laboratory Tests.—The laboratory investigations of Davey(2), Paul(12), White(11) and Ferguson(16), in which cement temperature was the variable, are in accord that cement of high temperature does not affect the strength of concrete with the exception that one of the two Ferguson tests, using cement at 210° F. gave 10 to 15 per cent lower strength at 7 and 28 days.

Standard Strength and Setting Time Tests.—Of those laboratories making standard strength tests with cement of different temperatures, Tennessee Highway Department(1), White(11), Miesenhelder(14) and Paul(12) found no effect while Davey(2) found about 10 per cent lower strength with the higher temperatures. Davey, Mattimore(8), White, Miesenhelder and the Committee on Materials and Construction of the Highway Research Board(13) (some investigations include both cement and water of different temperatures) found that the rate of setting increases with the temperature. Tennessee Highway Department found slightly earlier setting times while Paul found no effect. Although these studies are of interest and value it is difficult to interpret the results of small laboratory batches of neat paste and of standard sand mortar in terms of the behavior of concrete in the field.

Quantity of Mixing Water.—In the laboratory concrete studies Davey(2, 3), Bachelder(4), McMillan(5), White(11), Paul(12), Moore(6), and the Committee(13) found that more mixing water was required to maintain the same slump or flow with the higher temperatures of freshly mixed concrete. No difference was noted by Ferguson(16).

Temperature of Freshly Mixed Concrete.—In the laboratory investigations of Bachelder(4), Davis and Troxell(9), McMillan(5), and Moore(6), temperature of freshly mixed concrete was the variable factor, obtained by heating all of the materials. Although these investigations do not apply directly to the question before the section they are of interest in so far as cement temperature plays a part in determining concrete temperature. The data cover a wide range of temperatures (70 to 165° F.) of freshly mixed concrete in about

30° F. increments and are quite consistent in showing increased early strength and decreased later strength for temperatures of 130 and 165° F. Little, if any, effect is indicated until the temperatures are well above 100° F. The reduction in strength for the higher temperatures appears to be due in part to the additional water required to maintain the consistency desired.

It seems evident that the heat contained in the cement, in the mixing water and in the aggregates, and heat losses during mixing, determine the temperature of freshly mixed concrete, neglecting the small amount of heat generated by the mechanical mixing and by any hydration of the cement. The relative effect of the various ingredients in a given batch upon the temperature of the freshly mixed concrete will depend upon their weights, their temperatures, their specific heats (water = 1.00, cement = 0.2, aggregate = 0.2) and upon heat losses. For ordinary mixes the effect of a relatively high cement temperature is offset to a marked degree by the specific heat of water which is five times that of cement and by the weight of the aggregates which is several times that of the cement. For example, if heat losses are neglected and if the temperatures of all of the ingredients in a 1:2:3.5 (dry-rodded volume) concrete, water-cement ratio = 0.8, are the same, the relative effect of the cement upon the temperature of the freshly mixed concrete will be approximately 10 per cent, of the mixing water 27 per cent and of the aggregate 63 per cent. If the temperatures of the several materials in the above example were at 100° F. and cement of 200° F. is substituted for cement of 100° F. then the relative effect of each ingredient will be approximately as follows: cement 19 per cent, mixing water 25 per cent and aggregate 56 per cent. The temperatures of freshly mixed concrete have been calculated for those investigations recording detailed data and have been compared with the observed temperatures, neglecting heat losses. In the Davey(2) laboratory tests the observed and calculated temperatures check closely, 90° F. and 89° F., respectively. The Litehiser(15) observed temperatures in the laboratory check the computed temperatures as follows: 91° F. observed *versus* 94° F. computed; 89° F. *versus* 86° F.; 94° F. *versus* 93° F.; 85° F. *versus* 83° F. and 91° F. *versus* 88° F. In the Moore laboratory tests the values check exactly from 78° F. up to about 90° F. Above this figure the values gradually diverge, the calculated temperatures being higher and the differences being 1° F. higher at an observed temperature of 93° F. and 7° F. higher at an observed temperature of 102° F. The differences, no doubt, are due to heat losses. The Miesenhelder(14) field temperatures check the calculated temperatures quite consistently, as for example: 76° F. observed *versus* 73.4° F. computed; 89.1° F. *versus* 89.0° F.; 85.1° F. *versus* 83.6° F.; 94.4° F. *versus* 96.6° F. Some of the field temperatures of Ferguson(16) check while the observed temperatures of others are much lower than the computed temperatures. In the August 5 tests of the latter, the results check exactly at 92° F. but when the high-temperature cement was used the observed temperature was 94° F. and the calculated temperature 97° F. In the September 5 tests of Ferguson, the observed temperatures, 84 to 92° F. are 6 or 7° F. lower than the calculated temperatures. The day was clear and hot with a warm breeze blowing and considerable evaporation of the mixing water was noted. The low observed temperatures would seem to indicate excessive heat losses, which is the theory expressed by Ferguson.

CONCLUSIONS

The data studied seem to warrant the following conclusions:

1. The temperature of freshly mixed concrete rather than the temperatures of the separate ingredients appears to be the factor which influences the properties of the concrete.

2. The temperature of freshly mixed concrete depends upon the temperatures, specific heats and weights of all of the materials entering into the concrete.

3. Increasing the temperature of freshly mixed concrete decreases the slump and flow.

4. Increasing the temperature of cement paste accelerates its rate of setting.

5. There appears to be little effect on strength until the temperature of the freshly mixed concrete is well above 100° F. At 130 and 165° F. the one-day strength was increased but at later periods the strength was decreased; the compressive strength was more affected than the modulus of rupture. The decrease in strength at the higher temperatures appears to be due in part to the additional water required to maintain a given consistency.

6. On account of the low specific heat of portland cement and of its relatively small quantity in the usual mix, the temperature at the time of use of portland cement of normal properties appears to be a minor factor in producing high temperatures of freshly mixed concrete under usual job conditions.

7. Temperature at time of use of portland cement of normal properties was unimportant under job conditions covered by this report.

Respectfully submitted on behalf of the section,

O. L. MOORE,
Chairman.

APPENDIX

DIGEST OF INVESTIGATIONS ON EFFECT OF TEMPERATURES OF CEMENT AT TIME OF USE

(1) Tennessee Highway Dept., "Study of Hot Cement," *Proceedings,* Am. Concrete Inst., Vol. 25, p. 434 (1929). (Quoted.)

An investigation of the characteristics of hot cement when ground from (1) raw clinker direct from kiln, (2) 50 per cent raw, hot clinker and 50 per cent aged, cooled clinker from stockpile, and (3) clinker aged and cooled in stockpile. Two by 4-in. cylinders, standard briquets, and pats were made from cement ground from each of the clinkers at temperatures varying from 375° F. to normal by 25° F. decrements as the cement cooled immediately after manufacture. Standard strength tests were made on briquets and cylinders at 7 and 28 days, and time of setting and soundness tests were made on pats. The results showed that so long as the cement meets the physical requirements of the A.S.T.M. specifications, the temperature at which the cement is received on the construction job is not important. There was no material difference in either compressive or tensile strength, or in other characteristics. A slightly earlier setting time was found, but this is regulated under the A.S.T.M. specifications.

(2) N. Davey, "Hot Cement," *Bulletin No. 7,* Department of Scientific and Industrial Research (London), February, 1930; also *Cement and Cement Manufacture,* Vol. III, No. 3, p. 413, March, 1930.

These tests comprising laboratory tests and a full scale trial were made using British standard portland cement of various temperatures under the direction of the Building Research Station. Samples of cement were taken from the grinding mill conveyor, observed temperature 284° F., and sent to the mill laboratory and to the Building Research Station in specially made containers and vacuum flasks. Standard tests (British) were made on mortars and on concrete as the cement cooled, the temperatures at time of use ranging from 248° F. to 59° F. The cement temperature of tests made in the mill laboratory was 252° F. The concrete tests were made on 1:2:4 mix, 4 by 8-in. cylinders. In all tests where the high cement temperatures were used, the setting time was shorter and more mixing water was required. Tensile strength tests on standard mortars were lower but concrete compressive strength was not affected. The full scale trial comprised about 70 sq. ft. of concrete road alongside a landing stage, where it was liable to receive rough usage. The temperatures on this work were as follows: cement 239° F.; water 71° F.; dry mixture 104° F.; concrete 89° F. The slab was two-course, a rich mix, and was kept moist two days and then opened to traffic. After 11 weeks of heavy duty, a Building Research Station representative found no signs of cracks visible and no signs of disintegration, the concrete being in excellent condition. The conclusion given is quoted as follows: "In general it may be concluded that the effects of using 'hot' cement under conditions likely to be found on a job are unimportant."

(3) N. Davey, "Effect of Heating Materials and Appliances on the Rate of Hardening of Rapid-Hardening Portland Cement," *Concrete and Constructional Engineering,* Vol. 26, No. 6, June, 1931.

The tests recorded were undertaken to examine the effect upon rapid-hardening portland-cement concrete when materials are heated as in cold weather work. Three series of tests were made as follows:

Series 1. Concrete immediately after mixing 60° F., specimens stored in air at 60° F.
Series 2. Concrete at 158° F., stored in air at 60° F.
Series 3. Concrete at 158° F., stored in air at 158° F.

All materials in the batch were heated in an air oven. The mix was 1:6 by weight and the slump was held at 1 in. Test pieces were 6 by 12-in. cylinders, cast seven at a time and tested at periods from 3 hours up to and including 7 days. Series 1 required 50 per cent mixing water by weight of cement while Series 2 and 3 required 65 per cent. Conclusions: acceleration of strength in first few hours produced by preheating materials is striking and is much more pronounced when initial temperature is maintained by storage conditions. More water was required to mix at high temperatures and there appeared to be a marked stiffening of the concrete during mixing. Author points out that cements vary in quality and therefore results obtained might not be realized in similar tests. Also points out that cooling of concrete placed at high temperatures might result in excessive shrinkage stresses.

(4) W. H. Bachelder, "Overheating of Aggregates Found Detrimental to Concrete," *Engineering News-Record*, December 18, 1930, p. 973.

The article discusses a series of tests carried out in the Minnesota Highway Department laboratory to determine the effect of concrete temperature at time of placement upon its properties. All materials except cement were heated sufficiently to give concrete temperatures of 70, 100 and 130° F. when discharged from the mixer. The author points out that the temperature of mixing water is most important because its specific heat is much higher than that of the other ingredients. It was found necessary to add more water to the warmer mixes in order to obtain the same workability. The additional mixing water accounted for less than half the reduction in strength. Transverse and compressive strength test specimens were made and stored in a moist room at 70° F. Setting time as determined by flow specimens was shorter in the higher concrete temperatures. Conclusions are quoted as follows: "It is believed that the results of these tests indicate that concrete should not be placed too hot, that concrete placed at 130° F. loses approximately 20 per cent of its strength, and that the expense of insuring the proper temperature is justified."

(5) F. R. McMillan, "Tests of Concrete from Preheated Materials," *Series J104*, unpublished laboratory investigation, Portland Cement Assn., April, 1931.

This investigation comprises flexural and compressive strength tests on 1:1:2 concrete (dry-rodded volume) in which the aggregates were heated in a pan over a gas burner so that the temperature of concrete after mixing was 70, 130, and 165° F. The slump was held constant at 2 in. and the water-cement ratio allowed to vary. No conclusions are given but a study of the data shows that more water was required for the high-temperature mixes (nominal water-cement ratios 0.58, 0.64 and 0.68 in order of batch temperatures); that the strength tests at 1 day were higher for the higher temperature concrete but lower for following periods. The percentage of reduction in strength was less for the transverse than for the compressive strength.

(6) O. L. Moore, "Effect of Temperature of Cement and Other Materials at Time of Use Upon Temperature and Properties of the Concrete," *Series 71-1*, unpublished laboratory investigation, Universal Atlas Cement Co., April, 1929.

In this series of tests all materials (cement, sand, pebbles and water) were heated in a pan to give concrete ranging in temperatures immediately after mixing from 87 to 102° F. The normal concrete, using room temperature materials, was 78° F. The mix was 1:2:3 (dry-rodded volume) and the nominal water-cement ratio was held constant at 0.96. The slump varied from 6½ in. for the normal concrete to 3½ in. for the 102° F. concrete. Compressive strength for all periods from 1 day to 1 year was about the same for the concrete of various temperatures. The following formula was used to calculate the temperature of concrete and was found to check the observed temperatures almost exactly up to about 90° F. Above 90° F. the observed temperature was lower due, no doubt, to loss of heat, so that with an observed temperature of 102° F. the calculated temperature was 109° F.

$$X = \frac{0.2\,(C\,t + S\,t_s + A\,t_a) + W\,t_w}{0.2\,(C + S + A) + W}$$

where X = temperature of concrete immediately after mixing in degrees Fahrenheit;
C = weight of cement in the batch in pounds;
S = weight of sand in the batch in pounds;
A = weight of coarse aggregate in the batch in pounds;
W = weight of water in the batch in pounds;
t = temperature of cement in degrees Fahrenheit;
t_s = temperature of sand in degrees Fahrenheit;
t_a = temperature of coarse aggregate in degrees Fahrenheit; and
t_w = temperature of mixing water in degrees Fahrenheit.

The data indicate that the temperature of cement plays a rather small part in the increase of temperature of the concrete under conditions usually encountered on the job, the ratio being 9 or 10° F. for cement equal 1° F. for the concrete. The general conclusion is that the temperature of cement under conditions likely to be found on the job is relatively unimportant.

(7) O. L. Moore, "Effect of Temperature of Aggregates and Mixing Water on Strength of Concrete," *Series 71-2*, unpublished laboratory investigation, Universal Atlas Cement Co., June, 1929.

In this series of tests the cement remained at room temperature (70° F.) throughout while the mixing water and aggregates were heated to produce concrete at a temperature of 100 and 135° F. Room-temperature materials produced concrete at 72° F. The mix was 1:2:3 (dry-rodded volume). The slump was held constant at 2 in., while the water-cement ratio varied from 0.78 for the normal concrete to 0.96 for the 135° F. concrete. Compressive and transverse strength tests up to 1 year show about the same results for 100° F. concrete as the 72° F. concrete but lower strength results for 135° F. concrete. The general conclusion is that the temperature of concrete as usually encountered on the job is unimportant. However, the data indicate that further study should be made of concrete having temperatures well above 100° F.

(8) H. S. Mattimore, "Effect of Temperature on Normal Consistency and Setting Time of Cement," unpublished laboratory investigation, Pennsylvania Department of Highways, June 8, 1931.

Tests were made on a number of samples of blended cement and two different brands of cement using mixing water at room temperature and mixing water heated to 100° F. Penetration and setting time tests, using Vicat apparatus, were made and reported. The setting time, both initial and final, was considerably reduced when the hot mixing water was used, as was also the penetration of the Vicat plunger. Two per cent calcium chloride was also used in several of the tests with no appreciable difference in the results. In a letter to Section IV submitting the data, Mr. Mattimore states that the effect of hot cement on setting time and normal consistency has its effect on the resulting concrete, which shows a rapid loss of water and is difficult to finish.

(9) R. E. Davis and G. E. Troxell, "Temperatures Developed in Mass Concrete and Their Effect Upon the Compressive Strength," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 576 (1931).

This paper deals primarily with temperatures developed in mass concrete and, therefore, does not apply directly to the subject "Effect of Temperatures of Cement at Time of Use." However, Series 3 deals with effect of initial temperature in mass concrete, and the following conclusion from the tests reported is of interest: "The temperature at which mass concrete is placed effects appreciably the strength, not alone at the early ages, but at the later ages as well. For the richer mixes in particular, a higher initial temperature leads to a lower strength at the later ages, though the reverse is true at the early ages."

(10) A. C. Irwin, "Heated Water Supplies Warmth During Moderately Cold Weather," *Concrete*, Vol. 38, No. 1, p. 24, January, 1931.

Although this article deals with heating the mixing water for cold weather concrete, it gives a formula for computing the temperature of mixed concrete which is of interest in studying the effect of cement temperatures. The formula is as follows:

$$x = \frac{w\,t + 0.22\,w'\,t'}{w + 0.22\,w'}$$

x = temperature of mass after mixing;
w = weight of water;
w' = weight of solid materials (cement, sand and stone);
t = temperature of water; and
t' = temperature of solid material.
(Specific heat of water = 1.00 and of solid materials = 0.22)

(11) W. L. White, Jr., "Effect of Hot Cement Upon Setting Time and Upon Tensile and Compressive Strength of Concrete," unpublished laboratory investigation, Medusa Portland Cement Co., July 7, 1931.

Tests were made using cement at about 250° F. and repeated from time to time as cement cooled to 59° F. Setting time results were much shorter at high temperatures, the initial being about 1 hour at 250° F. and 2 hours at 59° F. Tensile strength was about 20 per cent lower for the high temperature but compressive strength remained about the same for all temperatures.

Another laboratory investigation, September 17, 1931, cement temperatures of 70, 150 and 275° F., shows initial setting time reduced from 3:30 to 2:00; final from 6:15 to 5:35; tensile strength the same at 7 and 28 days but considerably higher at 1 and 3 days in the case of the higher temperatures, and compressive strength of standard mortar and of concrete (W/C = 0.95, 6 by 12-in. cylinders) approximately the same at the above mentioned periods. A slight stiffening of the concrete while mixing was noticed with the "hot" cement.

(12) Ira Paul, "Effect of Hot Cement on Mortar and Concrete," unpublished laboratory investigation, New York Department of Public Works, Division of Engineering, December 1, 1931.

Portland cement and mixing water were heated to different temperatures and tests were made for setting time of neat paste, tensile strength of standard mortar and workability, modulus of rupture and compressive strength of concrete. Conclusions are quoted as follows: "(1). Within the limits of the temperatures used there appears to be practically no effect of the hot cement or warm water on the initial and final sets of the cement or upon the 7- and 28-day tensile strength of the mortar. (2). Within the limits of the temperatures used and using only concrete of normal consistency as tested by the Paul penetrometer no bad effect is noticed on the strength of the concrete as determined from the 7-day modulus of rupture test or the 28-day compression test. (3). In order to obtain the same consistency and workability of concrete it was necessary to add more water to the warm mixes. When the temperature of the water was 100° F. and the temperature of the cement was varied from 68 to 160° F. an additional amount of water was necessary to obtain concrete of the proper degree of consistency. This is due to the fact that the specific heat of the water is greater than the specific heat of the cement."

(13) H. S. Mattimore *et al.*, "The Effect of Hot Cement on Time of Set and Concrete Quality," *Eleventh Proceedings*, Highway Research Board (1932).

Under certain conditions cement received on the work retains considerable of the heat generated during manufacture. Occasional temperatures as high as 150 to 200° F. have been noted. The purpose of this investigation is to ascertain what effect this heat has upon the setting time of the cement and the workability of the concrete in highway work. The report includes the comparative setting time of at least four different cements at temperatures of 70, 100, 150, and 200° F., mixed with water at 70, 100, and 150° F. The set is recorded at 25 minutes, 45 minutes, and at 10 minute intervals thereafter until initial set is attained. In order to simulate severe field conditions the specimens were stored in air at 100° F., with controlled humidity of from 45 to 50 per cent. Tests of the workability of concrete made with cement and water at the same temperatures as in the setting tests are also reported. Conclusions: "(1). With a constant water-cement ratio, increase of temperature of concrete, decrease workability. (2). Increasing temperature of cement paste accelerates the initial and final set." Recommendation: "The committee recommends that a maximum temperature of concrete for use should be specified."

(14) P. D. Miesenhelder, "Investigation of the Effect of Hot Cement in Road Paving," unpublished field investigation, Indiana State Highway Commission, Dunes Relief Highway, *Project 193D*, September 4 and 8, 1931.

The question has arisen, principally among highway departments, as to advisability of using cement of high temperatures and some highway departments have considered limiting cement temperatures to 125° F. at the mixer. Cooling cement at the mill probably complicates handling and storage to such an extent as to increase cost to the user. Cooling by the contractor would cause added expense and probably frequent delays in construction. The use of hot cement is said to produce concrete of a rubbery, gluey or sticky consistency, making the finishing process difficult.

Also, instances have been reported of unusual rapid setting or stiffening and some believe that excessive volume change might be caused, resulting in a shorter crack interval or checking, or both. Also, effect on strength has been questioned. This investigation was undertaken to obtain data on the effect of cement temperatures on properties of concrete used in paving under local conditions.

Four sections (9 in., 8 in., 9 in.) 20 ft. wide and each about 160 ft. long, two using cold cement and two using hot cement, were observed. Except as to cement temperatures, concrete in all sections was as nearly identical as is possible with modern paving equipment. The placing of cold-cement concrete (Section 1) was started about 11 A. M. September 4, 1931, and followed by hot-cement concrete (Section 2). The test was duplicated September 8, 1931 (Section 3, cold; Section 4, hot). The batch was seven sacks cement, 1284 lb. washed sand, 2107 lb. crushed limestone and 29.2 to 31.75 gal. of water. Concrete was mixed in a Rex 27E paver, the motor of which was cooled by the mixing water. Subgrade was sandy and, although wetted, water was withdrawn rapidly from the concrete. The properties of concrete studied in each section were: workability, compressive strength, modulus of rupture, volume change and checking and cracking. Eighty cylinders and 20 beams were made, and three gage lines, together with copper tubes to serve as thermometer wells, were installed in each section for 20-in. strain gage readings. Three cores were drilled from each section at the age of 6 weeks, stored outdoors and tested at 3 months. Samples of cement used were sent to the laboratory in vacuum jugs for standard tests but there was only 7° F. difference in temperature upon arrival of samples at the laboratory. For this reason a portion of the hot cement was reheated in an oven and standard tests made. Results are summarized as follows:

Standard Tests on Cement.—The initial set was hastened slightly by the heated cement but tensile strength results were practically the same.

Workability.—No rapid setting approaching flash set was encountered at any time and no consistent relation was observed between cement temperature and slump of concrete. On September 4, workmen expressed the opinion that the hot-cement concrete was more easily handled than the cold-cement concrete. Finishers using wood floats and workmen doing the edging said that these operations had to be done more promptly than was necessary in the cold-cement section. Inspector was of the opinion that there was no difference in finishing of the two sections except the difference in time at which finishing was necessary. He felt that this was neither an advantage nor a disadvantage so far as quality of the finish was concerned. On September 8, when placing the cold-cement section, the finishers raised the objection that set was occurring more rapidly than was usual and that the concrete was sticky, which condition caused the concrete to stick to the floats and required that this operation be done rapidly. Water was not coming to the surface as preferred by the finishers. This was the first instance of criticism of any consequence, and attention is called to weather conditions which were sunny, accompanied by a hot wind and low relative humidity. During the placing of the hot-cement section the workmen shoveling concrete seemed to think the material was harder to handle than the cold-cement concrete. Because of the experience with the cold-cement section it was expected that the finishers and edgers would encounter aggravated difficulties. Just the opposite was the case. During the finishing of the entire section the workmen said the concrete was more easily finished than the cold section. At no time did the sticky or gluey condition occur. The inspector was of the opinion that the hot-cement section was finished more satisfactorily and called attention to the fact that no dry spots were present following the floating operation as had been the case in placing the cold-cement section. At no time did any of the workmen know what kind of cement was being used, since this information was purposely withheld. The dry, hot wind had subsided by the time the hot-cement section was started. From observation of conditions and from comments of the workmen it would seem that weather conditions are responsible for such impaired workability as occurred rather than cement temperature.

Initial Temperature of Concrete.—It is interesting to note the agreement between the observed and computed initial temperatures of concrete. The temperatures were computed by means of a formula supplied by the Universal Atlas Cement Co. (Formula given in digest of Moore investigation(**6**)).

Strength.—The test results on cylinders, beams and cores are recorded in Tables I and II.

TABLE I.—COMPARISON OF RESULTS OF CONCRETE CYLINDERS AND BEAMS.

Age	Strength, lb. per sq. in. Cement		Average Mean Variation, per cent		Ratio: Hot/Cold
	Cold-Cement Concrete	Hot-Cement Concrete	Cold-Cement Concrete	Hot-Cement Concrete	
	Compressive Strength[a]				
7 days	4500	4555	7.79	2.24	1.012
14 days	5450	5640	2.99	2.10	1.034
28 days	6130	6560	4.10	3.74	1.070
3 months	7740	7700	4.78	5.64	0.995
1 year	....	....	....	....	.....
	Modulus of Rupture[b]				
7 days	720	650	4.86	3.89	0.903
14 days	683	713	9.99	9.56	1.043
28 days	786	742	3.30	5.25	0.944
3 months	797	778	5.39	3.92	0.976
1 year	...	...	....	....	.....

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[a] Average of eight determinations.

[b] Average of four determinations.

TABLE II.—RESULTS OF TESTS ON CORES, 4⅜ BY 8¾ IN.

(Age at test: 90 days).

Property	Cold-Cement Concrete	Hot-Cement Concrete	Ratio: Hot/Cold
Compressive strength, lb. per sq. in.	5709	5458	0.955
Average mean variation, per cent	4.61	4.36	
Absorption after 24 hours immersion, per cent	1.527	1.616	1.059
Average mean variation, per cent	3.91	7.30	
Apparent specific gravity	2.400	2.392	0.996
Average mean variation, per cent	0.226	0.502	
Unit Weight, lb. per cu. ft	149.8	149.3	0.996
Average mean variation, per cent	0.226	0.502	

NOTE.—Each tabulated result is the average of 6 determinations.

The difference between strength of cores and 6 by 12-in. cylinders may be due to differences in size, curing and condition of test.

Volume Change.—All gage lines expanded during wet-straw curing and contracted when the straw was removed. Results of the three gage lines in any one section are not in close agreement, which is usual. All values are corrected for temperature change. Volume change in the beams followed the slabs except that contraction of the beams was about three times that of the pavement. The data to date (age 34 days) do not justify a distinction between volume changes in sections of cold-and hot-cement concrete.

Checking and Cracking.—No checking occurred in any of the sections and a survey at 32 days indicated no difference between cold- and hot-cement concrete. Unless a pronounced difference in cracking of cold- and hot-cement sections develops, conclusive results will be doubtful because of short length of sections.

TABLE III.—SUMMARY OF OBSERVED DATA.

(All temperatures are in deg. Fahr.).

DATE PLACED	SECTION NO.	TYPE OF CEMENT	TIME PLACED	LENGTH, FT.	TEMPERATURES AT MIXER			
					CEMENT	AGGREGATE	WATER	AIR
Sept. 4..	1..	Cold...	10.47 A. M. – 1.10 P. M.	175	77.0	68.7	83.9	71.6
	2..	Hot[a]...	1.18 P. M. – 3.45 P. M.	184	154.0	73.6	96.7	78.0
Sept. 8..	3..	Cold...	12.00 noon – 1.55 P. M.	141	80.4	77.4	101.5	87.1
	4..	Hot[a]...	1.57 P. M. – 3.30 P. M.	145	167.4	80.6	102.4	90.4

DATE PLACED	SECTION NO.	TEMPERATURE OF CONCRETE IMMEDIATELY AFTER MIXING		RELATIVE HUMIDITY OF AIR, PER CENT	WATER USED PER BATCH, GAL.	SLUMP, IN.	WEATHER CONDITION	TEMPERATURE OF CONCRETE AT AGE OF 24 HOURS
		OBSERVED	COMPUTED					
Sept. 4..	1........	76.0	73.4	82.0	29.20	1.6	[b]	80.2
	2........	89.1	89.0	69.2	29.50	2.8	[c]	76.0
Sept. 8..	3........	85.1	83.6	46.7	31.75	3.7	[d]	91.5
	4........	94.4	96.6	50.8	31.38	2.4	[e]	91.8

[a] Average temperature upon removal from the bin 186° F. (range 180 to 190° F.).

[b] At start: cloudy and slight breeze. Air temperature increased constantly. During latter half: sunny and increased wind.

[c] Mostly sunny and windy.

[d] Sunny and hot dry wind.

[e] Partly cloudy—breeze.

Conclusions (Quoted).—These data (to the age of 3 months) do not indicate that, under the conditions described, the use of hot cement (maximum temperature at the mixer 167° F.) is of consequence in road paving as it affects workability, compressive strength, volume change, checking, and cracking. On the only occasion in which impaired workability was encountered in this investigation, cold cement was being used and apparently adverse weather conditions were responsible for such difficulties as were encountered. It is likely that such weather conditions would have a similar and possibly a more pronounced effect on the workability of concrete in which hot cement was being used. The compressive strength of the hot-cement concrete as indicated by 6 by 12-in. cylinders was slightly greater at 7, 14 and 28 days, but at the age of 3 months was essentially equal to that of the cold-cement concrete. The results of the compressive tests on cores (at 3 months) indicate the cold-cement concrete to be slightly stronger. The volume changes that occurred in the sections of cold- and hot-cement concrete did not differ sufficiently to warrant a distinction. Checking did not occur in any of the sections of cold- or hot-cement pavement and the crack survey at 32 days, although conducted over shorter lengths of pavement than are desirable for this purpose, indicated no distinction between the two kinds of concrete. The effect of the hot cement was to reduce to some extent the modulus of rupture. These results of the study of flexural strength indicate that the use of hot cement may be slightly detrimental to this property of concrete, especially at early ages. The fact that the difference between the moduli of rupture of the two kinds of concrete decreases with increase in age indicates that at later ages the moduli may be equal.

In considering these conclusions if should be borne in mind that the tests were conducted during a season of the year when maximum summer temperatures do not occur. The average air temperature during the placing of the two hot-cement sections was 84° F. Perhaps, during the middle of the summer when the maximum air temperature in this locality is somewhat higher, different results might be obtained especially if the unusual air temperature is accompanied by dry wind and low relative humidity. However, the experience with cold cement on one occasion would lead to the opinion that such a combination of weather conditions would affect the workability of concrete in which the cement is at normal temperature.

(15) R. R. Litehiser, "Investigation of the Effect of Hot Cement in Concrete," unpublished laboratory investigation, Ohio Department of Highways June-July, 1931.

Concrete made from materials of different temperatures was mixed in $1\frac{1}{2}$-cu. ft. batches from each of which two blocks, 7 by 14 by 14 in., were made. The blocks were placed in the open immediately after making and one from each batch was cured for 2 weeks with wet burlap while the other block received no curing treatment. Five batches were made using a cement factor of 6.1 sacks cement per cubic yard of concrete, which is required under Ohio State specifications for a $1:5\frac{1}{2}$ mix. Water-cement ratio was 0.76 and the average slump 4 in. Other data are given in the following table:

	Batches				
	No. 1	No. 2	No. 3	No. 4	No. 5
Cement temp., deg. F......	250	160	190	86	87
Coarse aggregate temp., deg. F.	78	78	83	83	84
Fine aggregate temp., deg. F..	76	75	80	80	82
Mixing water temp., deg. F..	79	79	84	83	102
Air temp., deg. F...........	80	86	85	86	92
Concrete temp., deg. F.....	91	89	94	85	91
Relative humidity, per cent..	53	62	62	66	71
Mixing time, minutes.......	3	3	3	3	3
Time of placing............	4.30 P.M.	11.30 A.M.	10.00 A.M.	11.00 A.M.	11.00 A.M.
Date placed...............	6–18–31	6–19–31	6–26–31	6–26–31	7–2–31

The blocks were located in the laboratory yard, exposed to the sun all day. All showed hair checking to a more or less degree within the first 24 hours. Batch No. 3 (cement temperature, 190° F.) developed more checks than any of the others. However, there were fewer checks and these checks were shallower in the case of the block cured with damp burlap. In general this was true of all blocks cured under wet burlap. Two faults with the investigation are pointed out, first, the shape of the blocks should have been such as to expose more surface to the air in proportion to volume; second, batch No. 1 should have been placed shortly before noon as was done in the case of the other batches. Conclusion (Quoted): "While our investigation has been conducted on a rather limited scale and is faulty in some respects, nevertheless, we feel we are justified in concluding that cement with a temperature of 190° F. does not promote checking or cracking in concrete, where immediate and thorough curing is provided. We expect to continue this investigation during the coming summer season."

(16) L. R. Ferguson, "Effect of Hot Cement on Concrete," unpublished field and laboratory investigations, Lone Star Cement Co.

(*a*) Tarrant County, *Project S.P. 774-F*, Texas, May 29, 1931.

About eight batches of concrete (five and six sack batches) were placed from 1 to 5 P. M. (weather, cloudy, shower at 4 P. M.) using cement trucked direct from the mill. The temperatures of cement at time of use were around 100° F. and 250° F. Mixing water and air temperatures were about 80° F. and those of the concrete 80° F. for cold cement and 90° F. for the hot cement. The concrete was designed to contain 4.9 sacks cement per cubic yard and 5.25 gal. water per sack of cement. Slump was $\frac{1}{2}$ to $1\frac{1}{2}$ in. One batch out of three using the hot cement tended to set up very quickly and the finish was poor. The testing engineer on the job expressed doubt as to the value of further field tests in determining the effect of hot cement because of the many variables encountered and he suggested laboratory tests for any further studies.

(*b*) Houston Humble Road, Highway No. 35, *Project F.A.P. 514-D*, Texas, August 5, 1931.

Concreting started 10.30 A. M. with cement temperature 110° F. and aggregates, mixing water and air temperatures 90° F. At 11.10 A. M. 160° F. cement (temperature in the skip) was substituted for 110° F. cement and its use continued until 5 P. M. A total of 570 ft. of 20-ft. pavement was placed during the day. No change was necessary in the amount of mixing water when the cement was changed, no noticeable change in workability occurred and no difficulties were encountered. Compressive strength of cylinders averaged about the same as for the remainder of the work using cement of lower temperature.

(*c*) Lubbock, Highway No. 9, *Project F.A.P. 613-D*, Texas, September 5, 1931.

The job was started in the morning with cement from a car which had been cooled prior to shipping. At 11.35 A. M. hot cement was substituted and continued until 2 P. M. The weather was clear and hot with a warm breeze blowing, and the temperature increased steadily until the test was terminated. On September 4, a report of weather conditions on the work reads as follows: "Heat convections given up by the ground formed a screen which looked as though the entire country was covered with water." The increasing air temperature made it necessary to add more water, which is the usual practice, 0.5 gal. at 11 A. M. and 1 gal. at 1.20 P. M. Water tests on the concrete indicated that the additional water was evaporating. There was no additional water required when the change to hot cement was made and no indication that the hot cement affected the workability of the concrete. The test was terminated shortly after 2 P. M. The observation data taken September 5 together with strength results of the regular job specimens are as follows:

Observed Data

Time	Cold Cement 10.05 A. M.	 11 A. M.	 11.30 A. M.	Hot Cement 1 P. M.	 2 P. M.
Cement temperature, deg. Fahr.	122	122	124	176	177
Air temperature, deg. Fahr.	90	94	95	96	99
Water temperature, deg. Fahr.	86	91	96	101	106
Concrete temperature, deg. Fahr.	84	86	86	92	92
Subgrade temperature, deg. Fahr.	94	102	106	121	125
Slump, in.	1½	⅞	1	⅝	⅝
Water in concrete, gal.	..	31.8	..	31.8	31.8
Water added, gal.	0	0.5	0	..	1
Relative humidity	51 per cent at 7 P. M.; 43 per cent at noon.				

Compressive Strength Data, lb. per sq. in.

Date	No.	7-Day Beams	28-Day Beams	28-Day Cylinders
September 3	3	643	892	4880
September 3	4	662	909	4435
September 3	5	577	883	4680
September 4	6	829	888	4425
September 4	7	904	1000	4960
September 4	8	641	701	5020
September 5	9	652	770	6020
September 5	10	776	958	4870
September 5	11	691	805	5450
September 5	12	731	752	5010
September 7	13	666	859	4535
September 7	14	710	903	3900
September 7	15	633	875	4790
September 7	16	712	775	6120
September 8	17	788	925	4975
September 8	18	683	904	4850
September 8	19	816	802	5010
September 8	20	575	785	5490
September 8	21	571	721	4065
September 8	22	709	853	5440

(*d*) Galveston County, Highway No. 38, *Project F.A.P. 598-A*, Texas, September 15, 1931.

In conducting this test normal job conditions were followed and only the temperature of cement was varied. Due to a shut-down of the work on account of rain, the hot cement shipment cooled considerably. Observations were made at 12.30 P. M. using cold cement. Then hot cement was substituted at 1 P. M. and continued until 2.10 P. M. when cold cement was again used. The following observations were recorded:

	12.30 P. M. Cold Cement	1 P. M. Hot Cement	2.10 P. M. Hot Cement
Air temperature, deg. Fahr.	94	94	94
Water temperature, deg. Fahr.	106	106	92
Aggregate temperature, deg. Fahr.	86	..	88
Cement temperature, deg. Fahr.	108	152 to 160	152 to 160
Concrete temperature, deg. Fahr.	92	96	94
Slump, in.	1½	1	1

About 2.30 P. M. concrete became too stiff due to higher evaporation and more water was added. It was the opinion of all concerned that the hot cement did not affect the workability. Cylinders and beams tested about the same at 7 and 28 days as those made on September 14 and 16 except that the 7-day beam results were slightly lower for September 15.

(*e*) Laboratory investigations, May 1 and September 17, 1931.

This investigation consisted in a comparative test of concrete in which the cement was 200° F. in one set of cylinders and 80° F. in another set, other conditions being the same. The slump, the flow, and the 7- and 28-day compressive strengths were practically the same for both concretes.

Another laboratory investigation, September 17, 1931, consisted in a comparative test of 10 batches of concrete (about 2½ cu. ft. per batch, 6½ gal. water per sack, 1:2.7:4.5 by weight) in which the cement temperature ranged from 98 to 210° F. and the mixing water from 83 to 110° F. Room and aggregate temperatures were around 85° F. The slump, flow and 7- and 28-day compressive strengths were about the same except in the case of the two batches having 210° F. cement where the strength was 10 to 15 per cent lower.

(17) A. C. Blackall, "Effect of Temperature on Cement," *Concrete*, December, 1929, p. 110.
(18) "Hot Cement," *Engineering*, Vol. 130, No. 3376, p. 411, September 26, 1930.
(19) "Freshly Made Cement Is Proved No Cause for Worry," *Concrete*, Vol. 37, No. 4, p. 38, October, 1930.
(20) Editorial: "How Bulk Cement Is Handled in Highway Paving Work," *Concrete*, Vol. 38, No. 6, p. 27, June, 1931.
(21) Editorial: "Hot Cement," *Engineering News-Record*, Vol. 107, July 2, 1931.
(22) Editorial: "More Specifications," *Pit and Quarry*, Vol. 22, July 29, 1931.
(23) A. J. Blank, "Tests Show Hot Cement Not Harmful to Normal Concrete," *Concrete*, Vol. 39, No. 1, p. 59, July, 1931.
(24) "Research Advances Highway Economics," *Engineering News-Record*, Vol. 107, No. 25, p. 970, December 17, 1931.
(25) P. J. Freeman, "Developments in Highway Construction and Highway Materials," *Rock Products*, Vol. XXXV, No. 1, p. 68, January 9, 1932.
(26) "Hot Cement Has No Ill Effects in Concrete Paving," *Engineering News-Record*, Vol. 108, No. 7, p. 244, February 18, 1932.
(27) Editorial: "Hot Cement," *Engineering News-Record*, Vol. 108, No. 7, p. 236, February 18, 1932.
(28) "New Tests Show Safety in Using Hot Cement," *Science News Letter*, Vol. XXI, No. 571, p. 176, March 19, 1932.

REPORT OF SUBCOMMITTEE ON CEMENT REFERENCE LABORATORY

The Cement Reference Laboratory has continued to devote the major part of its efforts to the inspection of cement laboratories. Between April 6, 1931, the last date covered by the 1931 annual report of Committee C-1,[1] and March 17, 1932, requests for inspections have been received from 87 laboratories, making a total of 273 laboratories which have requested inspection since the start of the second inspection tour, December 1, 1930. Among these laboratories were 145 which had participated in the first inspection tour. Four requests have been canceled, and 21 inspections remain to be performed. A considerable number of requests have been received only within the last few weeks, and it is because of these unexpected demands that the number of uncompleted inspections is so large. Some of the recent requests are from territory already visited one or more times during the present tour.

TABLE I.—CLASSIFICATION OF CEMENT TESTING LABORATORIES REQUESTING INSPECTIONS.

Laboratories	First Tour up to November 30, 1930	Second Tour (in Progress) December 1, 1930 to March 17, 1932	Participating in Both Inspections
Producers	106	112	78
Commercial	49	50	27
State Highway[a]	23	61[b]	21
Schools	25	34	9
Municipal	11	11	6
Miscellaneous	5	5	4
Total	219	273	145
Canceled	7	6	

[a] In some cases the highway laboratories are also school laboratories.

[b] Some highway branch laboratories are located at producers' laboratories.

The laboratories which have requested inspection in this second tour are distributed over 47 states. Table I shows the classification of these laboratories, and indicates how many of these laboratories in each group have been involved in both inspection tours. Table II lists the quantities of apparatus tested.

A large increase in the amount of field work was recently brought about by the U. S. Bureau of Public Roads through its ruling that reports of acceptance tests of cement for Federal Aid road projects would be accepted only from those laboratories which had been inspected by the Reference Laboratory. Such inspections must have been made subsequent to October 1, 1930, and prior to April 1, 1932, and thereafter inspections will be required at intervals not to exceed two years. As evidence of such inspections there must be furnished copies of the inspection reports. Such report copies are distributed to the Bureau of Public Roads, also state highway departments when required, but only when the inspected laboratory authorizes such action. Since this ruling was made there have been received 51 inspection requests from laboratories in the group to which the ruling would most generally apply.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 299 (1931).

TABLE II.—APPARATUS INSPECTED FROM DECEMBER 1, 1930 TO MARCH 17, 1932.

	OBSERVED	APPROVED
Steam chests	240	150
Balances for fineness	152	126
Balances for mixes	317	167
Weights for fineness, pieces	2369	2262
Weights for mixes, pieces	3461	3341
Graduates	645	583
Vicat apparatus	304	143
Gillmore needles, pairs	314	201
Briquet molds	9925	7988
Tensile machines	241	149
Total	17 968	15 110

A few laboratories which have been inspected in the current tour have already requested another inspection, but at this time no arrangements have been made for a third tour. Before another round is started it seems necessary to pause long enough to study some of the data collected in the first and second tours, and make such revisions and additions to the procedure and equipment as may be found advisable.

Work has been continuously carried on in the study of various methods of determining the fineness of cement. This problem is not only of great importance to the producers, but at present also interests some of the non-producer laboratories. The Reference Laboratory's efforts are being directed toward the development of a test which will not only give helpful information concerning the size gradation, but will also be practical, reasonably rapid and economical. However, until further work has been done with new apparatus just received no detailed report is justified.

The laboratory has cooperated with the subcommittees of Committee C-1 in bringing to attention and studying questions relating to apparatus and test methods.

Respectfully submitted on behalf of the subcommittee,

F. W. KELLEY,
Chairman.

APPENDIX

MANUAL OF CEMENT TESTING

Supplementing the Standard Methods of Sampling and Testing Portland Cement (C 77 – 32) of the American Society for Testing Materials[1]

Prepared by Committee C-1 on Cement and Accepted by the Society for Publication as Information with the Standard Methods. The Manual is not a Part of the Methods

Introduction

Portland cement is an important structural material which is manufactured and sold in large quantities under standard specifications. Essential adjuncts to the specifications are the standard methods of testing cement as faulty test methods are certain to lead to erroneous conclusions as to the quality of the cement. Many steps are involved in making cement tests and the results are greatly influenced by seemingly minor variations in procedure.

Cement testing is not an exact science. Existing test methods are, at best, crude tools and it must not be expected that exact agreement will be secured in tests by different operators or by the same operator at different times, even when made on the same sample and under the same conditions.

It is the purpose of this Manual to emphasize those factors which may affect results of tests and to call attention to less apparent influences which are important, but which are sometimes overlooked.

The recommendations of this Manual refer to the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77 – 32) of the American Society for Testing Materials.[1] They do not in any way supersede the standard methods of test, but are intended, rather, to supplement the physical tests and to suggest a procedure in certain sections where considerable latitude is permitted by the standards and to recommend methods which the committee has found to be satisfactory and conducive to greater uniformity.

The specifications for cement are intended to set forth minimum requirements which must be met. Cement testing laboratories should have on hand copies of current A.S.T.M. Standard Specifications for Portland Cement (A.S.T.M. Designation: C 9)[2] and Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77)[1]. Cement testers should be thoroughly familiar with these specifications and should use every care to follow the standards strictly, and maintain their testing equipment in good condition. If careless methods and faulty equipment are used and numerous short-cuts made, results will be irregular and may be found to fall below specification requirements and lead to the rejection of a good product. If 20 different operators make tests on the same cement and 15 of them find strengths well above the specifications and 5 find strengths below, it is likely that the latter have not properly standardized their tests.

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 25.

It is suggested that the different cement testers in a given city or district arrange to carry out tests on the same cement and exchange results. To be of greatest value such tests should not only be made by each operator in his own laboratory but also by all operators in a single laboratory where the equipment and test conditions are identical. Each operator should repeat his tests on several different days to see how closely he can check his own results. This procedure will do more than anything else to create an interest in standard methods and will be found effective in eliminating erroneous practices and in calling attention to defective apparatus. A suggested course of training for cement testers is given on pages 39 and 40.

To encourage a more intimate knowledge of the literature on portland cement, a selected bibliography is appended which lists some of the better known and more important sources of information on the subject. The bibliography is general in scope, but those who are primarily concerned with the testing of cement will find references to this phase of the subject grouped under the subdivisions, Physical Properties and Tests and Specifications.

A mass of information on many of the properties of portland cement including variations in tests, is given in "Data Considered by Committee C-1 of the American Society for Testing Materials in preparing the Standard Specifications and Tests for Portland Cement," published by the Committee in 1919.

SAMPLING

(See Sections 1 to 6, inclusive, of the Standard Methods of Sampling and Testing Portland Cement (C 77 – 32) of the American Society for Testing Materials)

1. *Weight of Sample.*—The standard methods require that test samples shall weigh at least 4 lb. The test sample may be an individual sample or a composite sample as ordered. Composite samples must consist of approximately equal weights of separate samples.

2. *Number of Samples* (Car, truck, boat and warehouse samples).—The standard methods permit the testing of composite samples from cars, trucks, boats, warehouses, etc., in which case samples of approximately equal weight must be taken from 1 sack in each 40 sacks or from 1 bbl. in each 10 bbl. and all samples so taken composited to form a test sample. Care should be taken to insure proper distribution of sampling points.

3. *Number of Samples* (Bulk Storage Samples).—Either individual or composite test samples may be used in testing cement from a bin or other bulk storages. Individual test samples must be taken from each 300 bbl. or fraction thereof, unless otherwise specified by the purchaser. Composite test samples must consist of two or more individual samples and must represent not more than 300 bbl., unless otherwise specified by the purchaser.

4. *Treatment of Samples.*—Test samples must be forwarded to the laboratory promptly in air-tight, moisture-proof containers. Small paper or cloth sacks must not be used. The sample should be marked plainly and identified completely on the outside of the container as to source and date of sampling. Also, a complete identification should be enclosed in the container. As it is important to keep variable influences at a minimum, the cement should be kept in the air-tight, moisture-proof containers from the time it is sampled until it is tested and made into specimens.

5. *Preparation of Samples.*—Prior to testing, the samples must be brought to room temperature, thoroughly mixed and passed through the No. 20 sieve.

All foreign matter and lumps which do not pulverize easily in the fingers must be be discarded.

Reference: J. R. Dwyer and Roy N. Young, "Inspection and Testing of Portland Cement," *Concrete*, Vol. 21, pp. 56 and 95, August and September, 1922.

FINENESS

(See Sections 13 to 18, inclusive, Methods C 77 - 32)

6. *Accuracy of Tests.*—Accuracy in sieving is required in all standardization and check tests, in comparative and routine tests. In order to make fineness determinations satisfactorily, the operator must possess considerable skill, which can be acquired only by practice. With proper care, an experienced operator should check himself within 1 per cent and generally within 0.5 per cent on portions of the same thoroughly mixed sample on the same sieve in duplicate tests. In general, it may be stated that if an accuracy of 1 per cent or better is required, it is necessary that standard calibrated sieves be used. Because of unavoidable variations in the wire cloth, a small correction is generally necessary in order to bring the performance of commercial sieves into line with a standard sieve.

7. *Certified Sieves.*—Certain sieve manufacturers supply certified sieves with correction factor determined by the U. S. Bureau of Standards, Washington, D. C. The Bureau of Standards for a nominal charge will also certify sieves upon request of owners. Unless otherwise indicated, the corrections determined by the Bureau should be added to the percentage residue on the sieve when it has the plus sign and should be subtracted from the percentage residue on the sieve when it has the minus sign. Sieves having a correction of more than ±2 per cent should not be used. An occasional determination of the correction is desirable as an indication of the satisfactory condition of the sieve. Standard specifications for sieves are given in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

8. *Standard Fineness Samples.*—For the benefit of those who wish to determine the corrections to the sieving values of their sieves, the Bureau of Standards is prepared to furnish standard samples, having residues on the No. 200 sieve of approximately 5 per cent, and 20 per cent at the cost of $1.00 each. These samples are mailed in sealed glass bottles containing about 160 g. of cement (enough for three tests) and are guaranteed to be within 0.2 per cent of the true fineness as determined on the Bureau's standard sieves. Cement testing laboratories should keep a supply of these standard samples and should calibrate their standard No. 200 sieves with each of the two standard samples from time to time. A more general use of standard fineness samples is recommended for determining corrections to sieves and for preparing and standardizing auxiliary fineness samples for use in the laboratory.

9. *Machine Sieving.*—Machine sieving usually gives different results from hand sieving. For accurate machine sieving, therefore, it is necessary to determine a correction for sieve and machine together and to apply this correction, rather than the correction of the sieve alone, to the result obtained.

10. *Design of Sieves.*—It is essential that all sieves used in the determination of fineness of cement be well designed and constructed and that they be

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

provided with accurately fitting covers and pans in order to avoid the loss of small quantities of material during the sieving operation.

11. *Balance.*—In order to determine accurately the end point of the operation where not more than 0.05 g. passes through in one minute of continuous sieving, it is essential that a balance conforming to the requirements of the standard methods be used.

12. *Method of Testing.*—The following method of making the fineness test is recommended: Place a 50-g. sample on the No. 200 sieve, with pan and cover attached. Holding sieve in one hand in a slightly inclined position, sieve with a gentle wrist motion at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. Sieving in this manner should be continued until most of the fine material has passed through and the residue looks fairly clean. This operation requires 8 to 10 minutes, depending on the condition of the cement. Care should be taken that the sieving is not continued too long. More or less continuous rotation of the sieve is desirable throughout the operation.

When the residue appears clean, remove pan, hold sieve and cover firmly in one hand, tap the side of the sieve gently with the handle of the brush used for cleaning the sieve (a 2-in. bristle brush with an 8- or 10-in. handle is a convenient size). Dust adhering to the sieve will thus be dislodged, and the underside of the sieve may then be swept clean. Empty the pan and clean thoroughly with a brush. Replace the sieve in the pan and remove the cover carefully. If any of the coarser material has been caught in the cover during the tapping, see that it all gets back into the sieve. If the cement is in proper condition, there should now be no appreciable dust remaining in the residue nor adhering to the sieve or pan.

One-minute check tests should now be made as follows: The sieve, with pan and cover attached, should be held in one hand in a slightly inclined position and moved forward and backward in the plane of inclination, at the same time striking the side gently about 150 times per minute against the palm of the other hand on the up stroke. Regular rotation of the sieve is essential, and the practice of sieving about 25 strokes in 10 seconds by the watch, then turning the sieve 60 deg. and sieving for another 10 seconds, and so on throughout the one-minute tests, is conducive to uniform results. Sieves having covers with handles can be turned about the right amount without any trouble whatever, and flat covers may be marked with three straight lines through the center and intersecting at 60 deg. If one of the lines is marked with an arrowhead, and the habit is formed of starting this point under the right hand, one can easily keep track of the progress of the one-minute test. In the one-minute tests the sieve should be tapped rather than struck, for a gentle vibration of the sieve is all that is required. Any considerable blow on the sieve will throw the residue against the cover and very likely result in loss of material. The one-minute check tests are to be repeated until not more than 0.05 g. will pass through in one minute.

The essential points in the standard sieving operation may be summarized as follows:

(*1*) Rotation of the sieve throughout the process, and particularly in the 1-minute check tests.

(*2*) Guarding against loss of material. Most sieves are provided with covers which do not fit closely. If loss is suspected, sieve over white paper and always tap the sieve gently.

(*3*) A balance which conforms to the requirements of the Standard Methods (C 77 – 32).

(*4*) Washers, shot, and slugs should never be used on the sieve in standard tests.

(*5*) Avoid important tests on damp, rainy days. Excessive humidity and damp samples interfere with sieving and tend to decrease the percentage passing the sieve, and, in general, to produce irregular results.

13. *Care of Sieves.*—Sieves should be frequently examined for defects in the cloth. Holes or breaks are sometimes indicated by very noticeable irregularities in the end-point test weighings. Sieves should be kept thoroughly clean and dry. Dust and residue particles should be brushed from the sieve by means of a brush with bristles stiff enough to clean the sieve but not heavy enough to injure it. A 2-in. bristle brush with an 8- or 10-in. handle is very convenient for this purpose. New sieves should be cleaned with benzol to remove grease; alcohol is not recommended as it removes lacquer from the frame.

Reference: "Standardization of the No. 200 Cement Sieve," U. S. Bureau of Standards *Technologic Paper No. 42*, July 30, 1914.

MIXING CEMENT PASTES AND MORTARS

(See Sections 19 to 22, Methods C 77 – 32)

14. *Mixing Table.*—The height of the mixing table from the floor has a surprisingly large influence on the efficiency of the mixing and molding operation. A height of about 36 in. is correct for the average operator. For unusually short or unusually tall operators the height may be adjusted. The table top should be plane and should be made of non-absorbent material. Steel plate ¼ in. in thickness or plate glass ¾ in. in thickness is recommended for the tops of mixing tables. The mixing table should not be subjected to undue exposure to sun and drafts, or be placed too near radiators, hot plates, steam apparatus, etc. The table must be kept clean and free from adhering cement and oil.

15. *Balance.*—Balance and weights should conform to the requirements of the standard methods and should be kept clean and in good order at all times. Single 250, 300, 500, 750 and 900-g. weights may be used both for convenience and to minimize errors in reading weights on scale pan.

16. *Glass Graduates.*—The mixing water should preferably be measured in a glass graduate having a capacity not more than twice the volume of water required in the mix. A 150-ml. cylindrical graduate with full line type of graduations reading in one direction only is recommended, although some laboratories have found burettes of the dispensing type which discharge rapidly very satisfactory for measuring the mixing water. Graduates should be checked to see that they conform to the requirements of the standard methods. Laboratories should have a certified or carefully tested burette for use in checking new graduates. When measuring the water, the reading is taken by holding the graduate vertical and sighting through it along the bottom of the meniscus (the surface of the water at the center) and not at the outer edge of the meniscus where the water wets the glass. Rubber guards around tops of graduates will aid in avoiding breakage. The calibration of graduates is described in Paragraph 47.

17. *Gloves.*—Rubber gloves must always be used for mixing cement pastes and mortars. Gloves should be flexible enough so as to permit of easy movement of the fingers. Comfortable, well-fitting gloves are necessary for accurate work. Gloves should not be wetted before starting mixing. After using, gloves should

be well cleaned, and if they are of the cloth-lined variety they should be turned partly inside out when removing from the hands to permit drying of the interior. This will prevent rotting and unpleasant odor due to perspiration. Oil and grease will injure the rubber. Gloves containing holes should not be used.

18. *Size of Batch.*—A 500-g. batch should always be used for neat cement and not less than 1000 g. nor more than 1200-g. batches for mortar. The size of the batch is closely related to the possible thoroughness and uniformity of mixing, other conditions being the same, and is therefore not without its effects on the results of the tests. Small batches may lose relatively large amounts of water by evaporation, and by loss on gloves and slabs. On the other hand, with the same amount of time and mixing much larger batches may not be so thoroughly or so uniformly mixed. Longer mixing would probably be required for the larger batches, and another variable would be introduced. Moreover, the longer time required to mold the larger batches into specimens may result in considerable evaporation of water, stiffening of the cement through setting action and an accompanying decrease in the ease of molding and in the uniformity of the results.

19. *Dry Mixing.*—The batch must be thoroughly mixed dry, prior to the introduction of the water. The materials should not be scattered widely, but neatly and thoroughly mixed by turning with the trowel, and by rubbing them lightly upon the mixing table with the hand until the mass shows by its uniform appearance that the ingredients are well mixed. This method will cause less segregation than rolling the dry materials on a paper. A crater which will hold the entire desired quantity of mixing water without overflow or loss should be then formed in the dry materials.

20. *Mixing Water.*—In general, water fit for drinking is satisfactory for cement testing. The amount of water present in a mix is of great importance, particularly with regard to the setting time and strength. Water largely in excess of the required quantity will prolong the setting time and lower the strength. Less than the proper amount of water may shorten the setting time and result in strength variations from the normal, the latter sometimes due to the difference in molding properties of the mortar. The amount of water used is expressed in milliliters (1 ml. of water = 1 g.), and is usually measured by volume. The range in variation in the amount of water required by most portland cements for the 1:3 standard sand mortar mixes is not large, and the water must be carefully measured. The amount of water in a mix may be unintentionally increased by using wet gloves, or by pouring the dry materials on a wet slab. Loss of water may be somewhat avoided by commencing the mixing of the dry materials and the water so as to spread as little as possible of the mix over the surfaces of the gloves and slab.

21. *Addition of Mixing Water.*—The whole of the mixing water must be poured at one time into the crater in the dry materials. The dry materials should then be turned, as quickly as possible, from the outside into the crater, by means of a trowel, covering all the water within 30 seconds. After the dry material has been thus turned into the water, an additional 30 seconds must be allowed for the absorption of the water before mixing is commenced. These 30-second intervals for covering and absorption must be strictly observed.

22. *Operation of Mixing.*—Thorough, continuous, and vigorous mixing with both hands immediately following the 30 seconds allowed for absorption of the water is essential to produce well and uniformly mixed pastes and mortars. Increase in the rate of mixing, or the time, will often produce increase in work-

ability, or may effect greater strength. If, however, mixing is carried to a point where evaporation of water and reaction within the cement lessens the moisture and workability to an appreciable extent, the time of set specimens may be drier than normal, and the tensile strength specimens cannot be so easily molded. A uniform method should be adopted in which an endeavor is made to put sufficient effort into the operation to accomplish the necessary amount of mixing in 1½ minutes. A timepiece should be used for these operations.

23. *Temperature and Humidity.*—The standard methods require that the temperature of the room and the dry materials shall be not less than 20° C. (68° F.) nor more than 27.5° C. (81.5° F.). The temperature of the mixing table and the apparatus should be within the foregoing limits. The temperature of the mixing water, moist closet and water in the briquet storage tank shall be maintained within ±1.7° C. (±3° F.) of 21° C. (70° F.). As the room temperature and humidity have a great effect on the behavior of the mixes, it is recommended that they be controlled within close limits in order to increase the uniformity of test results. Increase in temperature is accompanied by decrease in setting time, and usually by acceleration of strength. Drafts of air and low relative humidity will cause rapid evaporation of water from the mixes. Some laboratories have installed special automatic equipment in order closely to control room conditions. A relative humidity of 60 to 65 per cent has been found to be satisfactory.

STORAGE OF TEST SPECIMENS

(See Sections 22, 27, 32, 40, 41 and 42, Methods C 77 – 32)

24. *Moist Closets and Moist Rooms.*—A well-made moist closet or moist room is essential in cement testing in order to maintain the required relative humidity of at least 90 per cent. Pans of water in the top of the closet and pieces of wet wicking on the sides, and such similar methods as will bring large areas of wet surface in contact with the air of the closet are desirable features. Fog sprays may be used for maintaining the required humidity. When fog sprays are used, precautions should be taken to prevent condensed drops of water from falling on test specimens. The use of a recording wet and dry bulb thermometer of the rapid air type is recommended as a means of determining the relative humidity.

The doors should be well fitted and should be kept closed at all times except during the actual operation of introducing or withdrawing specimens. It is desirable to have separate compartments for the time of set specimens and the briquets, because of the necessity for frequently opening and closing doors of the compartment for time of set specimens in order to make determinations. The temperature of the moist closet should be maintained within ±1.7° C. (±3° F.) of 21° C. (70° F.). This may be accomplished by means of an automatic temperature control device

25. *Storage Tanks.*—Storage tanks should be made of non-corroding material, and may or may not contain racks for holding the briquets. Briquets should be completely immersed during the water storage period. The use of some form of temperature control device which will keep the storage water at a temperature within ±1.7° C. (±3° F.) of 21° C. (70° F.) at all times is recommended. Storage water and tanks should be clean and free from any substance which might possibly injure the briquets. Specimens containing materials possessing accelerating or retarding effects should not be introduced into the storage tanks with other specimens.

NORMAL CONSISTENCY

(See Sections 23, 24 and 25, Methods C 77 - 32)

26. *Vicat Apparatus.*—The Vicat apparatus should be inspected frequently, kept clean, free from rust and well oiled. The weight and diameter of rod should be checked to make sure that they conform to the tolerances given in Section 23 of the Standard Methods and the graduated scale should be checked for accuracy. Faulty results in determination of normal consistency are frequently due to defective or dirty apparatus.

27. *Method.*—Exactly 500 g. of cement must be used in the determination of normal consistency. For details of mixing, see Paragraphs 18 to 23, inclusive, of Manual. If a trial paste is too dry it should not be remixed with more water, but should be discarded. A new sample should be taken in order to avoid errors due to evaporation and other causes.

28. *Care in Determination.*—The accuracy of the normal consistency determination depends upon the proper mixing and placing of the cement paste in the mold, removal of the surplus with as little disturbance of the mass as possible, freedom of the apparatus from vibration, and careful manipulation throughout the test. Care should be taken to center the test specimen under the plunger and to release the plunger exactly 30 seconds after completion of mixing. The operator must possess considerable skill and dexterity in order to make this test satisfactorily. It is a very important determination, however, because upon it depends the percentage of water which is used for all the other determinations.

SOUNDNESS

(See Sections 26 to 29, inclusive, Methods C 77 - 32)

29. *Size of Batch.*—Not less than 500 g. of cement should be mixed with the hands using the quantity of mixing water determined by the normal consistency test. Since the specified minimum mix of 500 g. makes considerably more paste than is required to make a pat, 100 and 200-g. samples are sometimes mixed with a trowel or with the hands. This method usually requires more mixing water than that specified by the normal consistency test, which changes the rate of hardening of the pat. Results obtained in this manner are not standard and should be considered as only approximate. The shape and size of the pats should be as specified in Section 27 of the standard methods and the pats should be formed as shown in Fig. A. Small pats or pats with blunt edges do not readily show the effects of slight unsoundness. Clean, dry, unoiled plane glass plates should be used.

30. *Time in Moist Closet.*—The pats should remain in the moist closet 24 hours as specified. This is important since variations in age of the pats will produce differences in the results of the steam tests. Particularly noticeable are the effects of steaming pats too soon, for many specimens steamed when only 10 or 12 hours old give apparently satisfactory results, while failure would be observed if they were not placed in steam until 24 hours old. Pats should not be removed from glass plates prior to testing.

31. *Steaming Apparatus.*—The steaming apparatus should be capable of maintaining a constant temperature of 98 to 100° C. (208 to 212° F.) for 5 hours, The rack for supporting the pats should be the specified distance of 1 in. above the water level. The introduction of large quantities of water during the test. thereby lowering the temperature, should be avoided. A simple overflow or other constant level device should be used.

32. *Temperature Control in Steaming Apparatus.*—The temperature of the steaming apparatus should be checked with a thermometer, as a temperature considerably lower than 98° C. (208° F.) may exist even though the water is boiling and condensed vapor is escaping from the outlets. The apparatus must be at the required temperature before placing the pats under test. At high altitudes it may be impossible to reach a temperature of 98° C. (208° F.) at atmospheric pressure, and under these conditions a steaming apparatus in which a moderate pressure may be maintained is required for strict compliance with the specifications.

33. *Observations.*—Pats should be removed from the steaming apparatus at expiration of the 5-hour period and within 1 hour examined for indications of unsoundness. Unsoundness is usually manifested by a change in volume of the pat which causes distortion, cracking, checking, or disintegration. Pats improperly made or exposed to drying may develop what are known as shrinkage cracks within the first 24 hours and which are not an indication of unsoundness. These conditions are illustrated in Fig. 3 (*a*) in the standard methods. The failure of the pats to remain on the glass or the cracking of the glass to which the pats are attached does not necessarily indicate unsoundness. Figure 3 (*b*) in the standard methods illustrates the appearance of pats which have failed in the soundness test.

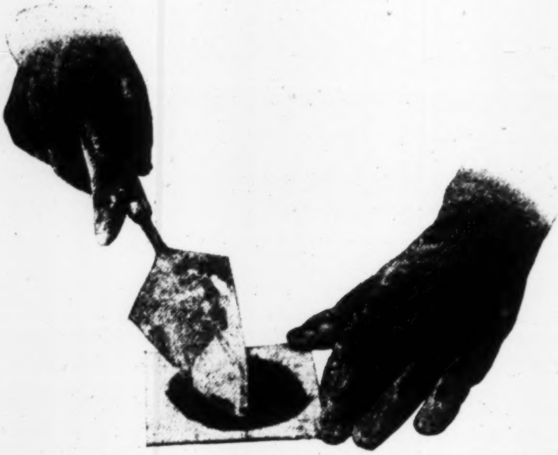

FIG. A.—Correct Method of Forming Cement Pat.

TIME OF SETTING

(See Sections 30 to 34, inclusive, Methods C 77 - 32)

34. *Vicat and Gillmore Needles.*—The specifications permit the use of either the Gillmore needle or Vicat apparatus. Weights and diameters of needles should be checked frequently to see if they comply with the requirements of Sections 23 and 33 of the standard methods; see also Paragraphs 48 and 49. It is sometimes found that even new needles are not standard either as to weight or diameter.

35. *Method of Mixing.*—The method of mixing and size of batch are fully discussed under Mixing Cement Pastes and Mortars, Paragraphs 18 to 23, inclusive, of the Manual.

36. *Method of Making Gillmore Specimens.*—The method of making pats is the same as described in Section 27 of the standard methods and in Paragraph 29 of the Manual except that the tops of the pats are flattened. There should be just enough trowelling to give the proper shape and a smooth surface in forming the pats. An overtrowelled surface or a rough surface may materially affect the apparent time of set. To flatten the top of the pat the paste should be pressed down with a trowel and the surface smoothed with a single stroke of the trowel. The flat surface of the pat should be parallel to the surface of the glass. Dry, unoiled, glass plates should be used.

37. *Method of Making Vicat Specimens.*—The method described in Section 24 of the standard methods should be strictly followed.

38. *Storage of Specimens.*—Specimens should be stored in the moist closet or moist room during the determination of time of set. See Paragraph 24 of Manual for precautions to be observed in connection with the storage of specimens. It is usually necessary to take the specimens from the moist storage when a determination is being made. However, they should not be left in the air of the laboratory but returned to the moist closet as soon as possible after the trial test has been made.

39. *Method of Testing.*—The needle must be held vertical and applied perpendicular to the surface without shock. This is especially difficult in the case of the Gillmore needle, and great care is necessary. The use of a frame, as illustrated in Fig. 4 of the standard methods will assist in this regard, provided the surface of the pat is horizontal. In determining the end point, the needle will give a crescent-shaped mark some time after the setting time should have been recorded, if not applied perpendicular to the surface. As long as any marking is noted on the pat when the needle is brought perpendicular to the surface it shall be considered that there has been an "appreciable indentation." For accurate determination of setting time, both Gillmore and Vicat, use of the cement paste from the normal consistency determination is not recommended.

40. *Interpretation of Time of Set.*—The Gillmore setting time shall be considered as the elapsed time between the finishing of the pat and the time when the needle after trials at several points on the pat first fails to make an appreciable indentation. The Vicat setting time shall be considered as the elapsed time between the finishing of the test specimen and the time when the needle after trials at several points first fails to penetrate within 5 mm. of the bottom of the specimen in the case of initial set or first fails to make an appreciable indentation on the surface of the specimen in the case of final set.

TENSILE STRENGTH TESTS

(See Sections 35 to 45, inclusive, Methods C 77 - 32)

41. *Briquet Molds.*—Briquet molds must be of the form specified in the standard methods (see Fig. 5) and should meet the tolerances for all dimensions given in Section 35. Molds should be frequently checked to see if they conform to the tolerances specified. A three-gang mold is the most convenient to handle. Clamps should be of a type which will close the joints in the molds completely so as to insure briquets of specified width (see Fig. 6 of standard methods). There should be enough metal in the sides of the molds to prevent distortion during use.

42. *Molding of Briquets.*—See Paragraphs 18 to 23 inclusive of Manual on mixing cement mortars. The molds should be placed on unoiled glass or

metal plates of sufficient thickness to withstand bending during molding and handling. Immediately after mixing the standard mortar, it should be heaped in the molds without compacting. Then the mortar should be pressed in firmly with both thumbs applying pressure 12 times to each briquet at points to include the entire surface. It is recommended that the pressures be applied in groups of two per briquet on each of 6 trips along the mold. Care should be taken that the thumb pressure is applied entirely to the mortar and not to surface of the mold. The standard methods require that the application of both thumbs simultaneously on the mortar, as illustrated in Fig. B, register a pressure of between 15 and 20 lb. The mortar should then be heaped above the mold and smoothed off with a trowel. The trowel should be drawn over the mold, as illustrated in Fig. C, in such a manner as to exert a pressure on the material of not more than 4 lb. A lightly oiled glass plate should then be placed on top of the mold and the mold with the two plates turned over and reversed as to position. The desired thumb pressure may be obtained by molding the briquets on a platform scale or on other suitable apparatus which will indicate the pressure exerted. The top plate should then be removed and the operation of heaping, thumbing, heaping and smoothing-off repeated. Where gang molds are used it is recommended that each gang of briquets be completed before the next is started. Sand grains should not be allowed to remain upon the face of the mold to which the plate is to be applied, as it may result in thick specimens and also cause a loss of water between the mold and plate. Care should be taken to see that the briquets when finished are exactly flush with surface of molds. The joints of the molds should be tightly closed, in order to insure specimens of correct width. Many operators find that a slightly curved trowel is of great assistance in making briquets because of the ease with which it can be used to clean off the mold faces, and smooth the mortar within the molds. Only mineral oil should be used in oiling molds and plates. When removing the briquets from molds they should be handled carefully in order to prevent partial fracture or other damage.

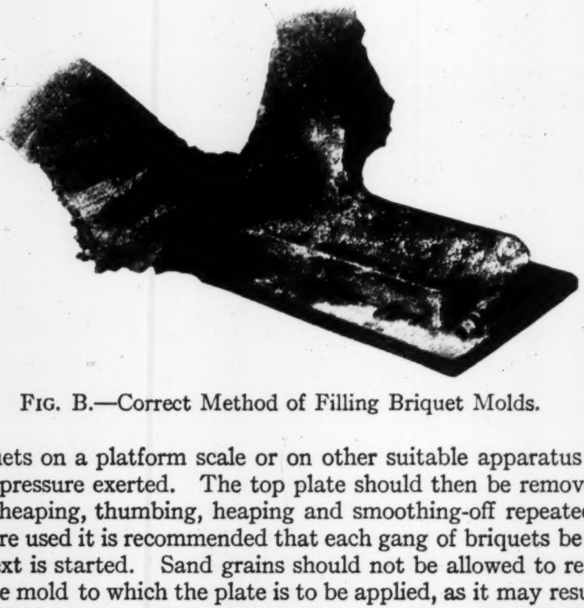

FIG. B.—Correct Method of Filling Briquet Molds.

43. *Storage in Moist Closet or Moist Room.*—It is intended that the molds containing the briquets should be stored so that the upper surfaces of the briquets are freely and uniformly exposed to the atmosphere of the moist

closet or room. Molds should not be piled one upon the other in such a way that the glass plates of the upper molds exclude the air from the briquets beneath. The briquets should be kept in moist closets until they have attained the age of 24 hours, when they are to be placed in the storage tanks. If removed from the molds before they are 24 hours old they should be replaced on the shelves of the closet until the expiration of the 24-hour period. In no case should they be removed from the molds until they are at least 20 hours old. The removal from the molds should be done with care, and with as little disturbance as possible as briquets at the end of 24 hours are not very hard and rough treatment may produce injuries which, although not apparent, will nevertheless affect the strengths. It will be found very convenient to mark the reference numbers on the mold plate faces of the briquets, after the plates have been removed, but while they are still in the molds.

44. *Testing Machines.*—The type of testing machine should be such as to comply strictly with the requirements of the standard methods as regards rate and uniformity of application of the load and other details. The clips should be provided with rollers ½ in. in diameter, with full bearing of 1 in. on the briquet, and mounted so as to permit easy turning during the test. (See Fig. 7 of standard methods). Many laboratories do not observe the latter detail sufficiently, with the result that eccentric strains are produced in the briquet and erratic results secured. Moreover, the distance between the rollers in the clips should not vary appreciably, and the clips should be so designed as to keep the rollers in parallel positions during the test. The bearings of the rollers should be well lubricated. Petrolatum or cup grease will be found quite effective. Grit in the bearings or lack of lubrication may produce undue stresses in a specimen, and often result in a jerky or non-uniform operation of a machine. Long use will sometimes so roughen or deform the rollers that they must be replaced. Daily balancing of the beam is a good habit to acquire. See Paragraph 51.

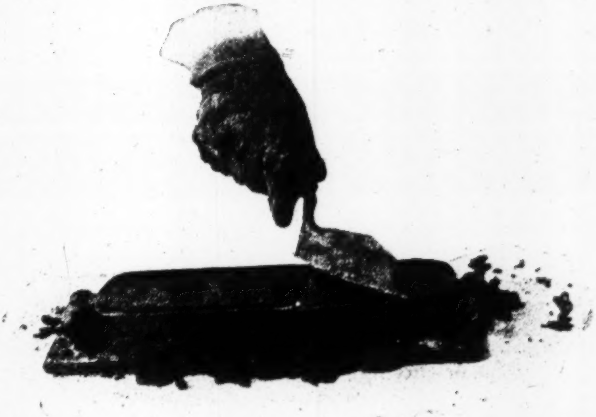

FIG. C.—Correct Method of Troweling Surface of Briquets.

45. *Precautions to be Observed in Testing.*—Briquets, except those to be tested at 24 hours, must be tested as soon as removed from the storage water. Briquets to be tested at 24 hours should be taken direct from moist closet and

tested at once without previous immersion in water. Where several 24-hour briquets are to be tested at one time it is recommended that they be removed from the moist closet, placed in a pan and kept covered with a moist cloth until ready for test. Indications of injuries, defects, or unusual appearances should be noted. When two or more briquets, other than 24-hour briquets, are to be tested at one time they should be removed from the tanks, placed immediately in a pan of water and kept there until actually tested. As it is important to prevent changes in temperature, it is recommended that briquets be covered with water from the storage tank. Briquets must be carefully centered in the clips, otherwise large variations in the stresses and consequently in the results are probable. Briquets must be inserted in clips so that the smooth surfaces which have been in contact with the mold plate are turned toward the back of the clips, and placed in contact with the guide bar at the back. Bearing surfaces of the briquets and of the rollers should be clean, smooth and free from sand or grit and the rollers well lubricated.

After the briquet is properly centered in the clips, just enough load should be applied by hand before starting the mechanically applied load, to take the play of the machine, and prevent jerky application of the load. Very weak briquets may not permit taking up the play of the machine, and must be handled carefully. Adjustments of the load control mechanism are often needed, and at least daily trials should be made before tests are commenced, to determine if the load is being applied at the specified rate of 600 lb. ± 25 lb. per minute. A quantity of flake graphite added to the shot hopper will aid the smooth and uniform flow of the shot.

CALIBRATION AND CARE OF APPARATUS

46. *Cement Reference Laboratory.*—It is important that the apparatus used in cement testing be kept in good condition at all times. Apparatus should be inspected at frequent intervals to see that it is functioning properly and that it conforms to the tolerances of the standard methods.

There has been established at the U. S. Bureau of Standards, Washington, D. C., a fellowship known as "Cement Reference Laboratory." Upon request of the directing head of a cement testing laboratory, this laboratory staff is prepared to instruct on established methods of making tests, proper methods of maintaining, checking and calibrating cement testing equipment. This service is available without charge upon application only and will be rendered as nearly as possible in the order in which applications are received. Application for service should be made to the Cement Reference Laboratory, care of Bureau of Standards, Washington, D. C.

In addition to this service, it is suggested that each laboratory check its own apparatus at regular intervals. To aid in this work, a brief description of methods used in calibrating cement testing apparatus is given.

47. *Graduates and Burettes.*—The U. S. Bureau of Standards *Circular No. 9*, "Testing of Glass Volumetric Apparatus" gives information on specifications, special requirements, tolerances and on other matters relating to such apparatus. This circular is now out of print but may be consulted in libraries. The following information from the 8th edition issued March 31, 1916, will be helpful to operators in calibrating water measuring apparatus:

Twenty degrees centigrade is regarded as the standard temperature for glass volumetric apparatus. The relation of height to diameter should be such that the graduation marks are not less than 1 mm. apart and also that the graduated height is at least five times the inside diameter. Graduations should read in one direction only and should be of uniform width, continuous and finely but distinctly etched or engraved and perpendicular to the axis of the cylinder. All graduations should extend at least halfway around and at least every tenth graduation entirely around the cylinder. The numbers indicating the capacity of the graduate should be placed immediately above the marks to which they refer.

Graduates should be calibrated with water to deliver the indicated volume at 20° C. (68° F.). In all apparatus where the volume is limited by a meniscus the reading is made on the lowest point of the meniscus. Apparatus must be sufficiently clean to permit uniform wetting of the surface and, in filling, the entire interior of the vessel should be wetted and allowed a sufficient time to drain before readings are taken.

In testing graduates and burettes, the capacity of any interval may be determined by weighing the water delivered by the interval in question. The water is delivered into a weighing flask of convenient size provided with a stopper. The temperature of the water is observed either immediately before or immediately after delivery from the apparatus. By means of Tables 40 to 52, U. S. Bureau of Standards *Circular No. 19,* 6th edition, October 31, 1924, the capacity of the apparatus is determined from the weight of the water delivered by the apparatus.

In making the weighings it is both convenient and accurate to use the method of substitution. By this method a constant tare is kept on one pan of the balance, while on the other pan is placed the object to be weighed and with it sufficient weights to secure equilibrium.

For details of methods of calibrating graduates and burettes, the operator should consult U. S. Bureau of Standards *Circulars Nos. 9 and 19.*

48. *Vicat Apparatus.*—Remove plunger from frame and weigh with the proper assembly of parts. Some Vicat apparatus are equipped with separate weights for use with needle or plunger. The plunger and needle diameters should be measured with a micrometer at the end and at several points over their entire lengths. The plunger and needle should be longer than the height of the mold, and must be straight with end surfaces flat and perpendicular to the axis. The edges should be true and sharp and the surfaces free from rust. The plunger should be clean, lightly oiled at contact with the frame and should slide freely through the guides. If plunger and needle assembly require considerable adjustment, weights should be rechecked after such adjustments have been made.

Examine the graduated scale, which should agree within 0.25 mm. at any point when compared with an accurately graduated measuring scale. Sometimes the overall length of the scale is quite accurate but the graduations are in error, 9 or 11 graduations being inserted in an interval which measures 10 mm.

Measure top and bottom inside diameters of molds at several points as well as height of mold.

49. *Gillmore Needles.*—Measure end diameters. The needle ends should be cylindrical for a distance of about $\frac{3}{16}$ in. and of the proper diameter. The end areas should be flat and at right angles to the axes of the needles with edges true and sharp. Needle stems should be rigidly held in the weights. After proper adjustments have been made to the needle ends, the needles should be weighed and any necessary weight corrections made.

50. *Briquet Molds.*—The molds, well cleaned, should be examined to see whether the halves are properly mated and the clips of such type and condition as will hold the halves tightly together. The widths at waist line should be measured, preferably and most readily with "stop and go" gages.

Compare molds with standard outline of briquet. Considerable difference in outline near ends may be encountered which is important in case weights of briquets are being compared. The mold outlines should conform closely with the standard at the points of contact with the rollers of the tensile machine grips. As these contact points will be about ½ in. above and below the center line of briquet, the briquet mold outline should compare closely with the standard in these regions. Paragraph 51 of the Manual gives requirements for roller diameter and spacing.

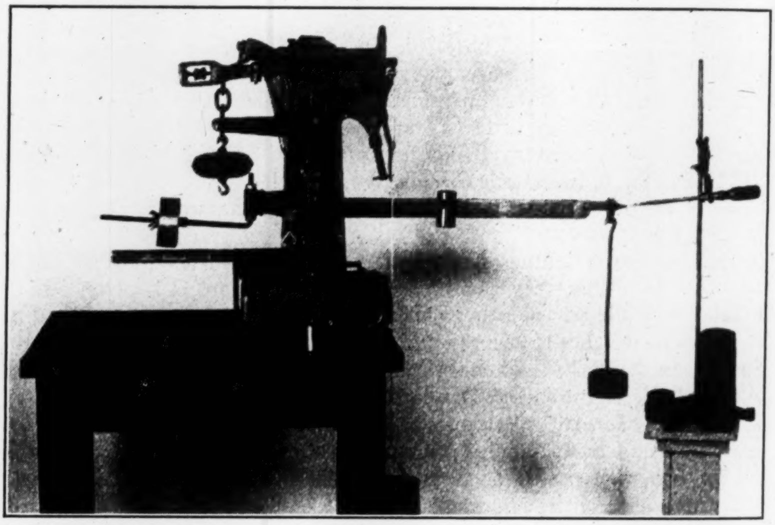

FIG. D.—Set-up for Calibrating Briquet Testing Machine with Test Lever.

Measure greatest thickness of each half of molds at points between inner and outer edges at the waistline of the briquet, opposite each briquet space.

51. *Tensile Strength Testing Machine.*—Thoroughly clean machine before examination. Inspect knife edges and bearings. Stirrups and knife-edge bearings should be free from nicks, dents or worn spots. Knife edges should be straight, sharp and tightly held in beams. Adjust the various parts of the machine so that the beam balances and swings freely at zero load. The method of balancing the machine will vary according to the type and model. Individual parts of the machine should be calibrated as follows:

Check *grips* with respect to condition, lubrication, dimensions and spacing of rollers. (See Fig. 7 of standard methods for details of important dimensions.) The rollers should be 0.5 in. ± 0.01 in. in diameter and should be approximately 1⅛ in. in length. The distance between the roller faces should be 1.25 in. ± 0.02 in. and the rollers should be parallel within 0.02 in. and should be in the same horizontal plane. Note if the bore of the rollers is straight and if rollers bear on pins throughout their length.

Check *pivots* with respect to center of briquets when in grips, particularly with respect to the front and back of specimen.

Make at least three determinations of the rate of *shot flow* using not less than 30-second intervals and timing by second hand of watch. The results should conform to the tolerance of the specifications. Inability to secure sufficient flow rate may be due to dirty or badly worn shot or to stoppage in outlets. A small quantity of flake graphite will assist in preserving the shot and facilitating flow.

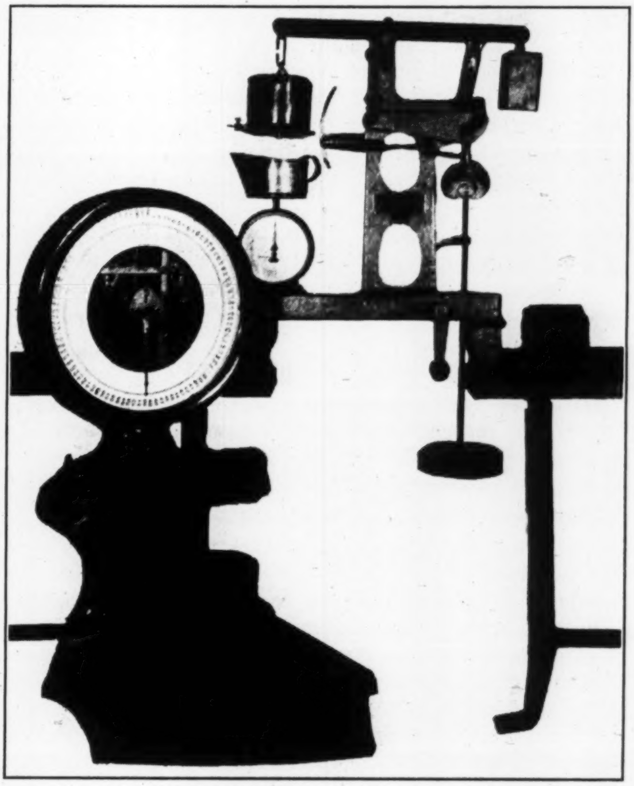

FIG. E.—Set-up for Calibrating Briquet Machine with Saddle and Weights.

Load tests may be made by means of a lever (see Fig. D), or by dead weights placed upon a support suspended from upper grip of machine either by a saddle straddling the base of the machine or by a rod as shown in Fig. E. In the latter method a metal briquet is placed in upper grip and a rod, passing through the base of the machine, is screwed into this briquet. A support sufficiently large to hold test weights is attached to the lower end of the rod. It is necessary to remove the lower grips and "take-up" gearing to accommodate this apparatus.

Loads should be applied in increments of not more than 100 lb. and the weight of shot required to counterbalance each load carefully determined. Make several determinations of the amount of shot required to balance the machine at each loading. After removing the loading lever or other device, ascertain what load indications are obtained with the amount of shot required for each of the loadings used. If the machine has both a spring scale and graduated beam device, record the readings by both devices. If the indicated loads are not within the tolerance, examine the various weights of the machine for discrepancies. If the error is constant for the various loadings, look for alterations in the machine, defective rider weights and see if proper balance was obtained at zero load. If the error varies, examine bearings and spring scale weighing device. The latter may be tested for irregularity in operation or graduation of dial by applying small increments of load and determining whether the indicated dial readings are proportional to the load applied. The weight of the test lever, suspension devices, etc., must be taken into account when computing the test load. The dead weights should be accurately known and not assumed to be exactly as indicated.

If machine cannot be corrected within the specified tolerances by minor adjustments, it is recommended that it be returned to the manufacturer for proper adjustments.

52. *Balances and Weights.*—It is recommended that a careful study be made of the various tolerances for balances and weights specified in the standard methods. For detailed information covering calibration of balances and weights, reference should be made to the U. S. Bureau of Standards *Handbook M 85.*

TRAINING OF CEMENT TESTERS

Considerable experience is necessary before an operator is able to secure consistent results in repeated tests on the same cement sample. Therefore, before assuming the responsibility of making tests which involve the acceptance of cement, the operator should be thoroughly trained in all details of the standard tests. The following outline of instruction is suggested:

1. Study thoroughly the Specifications, Methods and Manual.
2. Make normal consistency tests on several samples from the same lot of cement (at least 10 samples) until successive tests show the same results within 0.5 per cent of water. This will give practice in mixing and in preparing the sample for the time of set test by the Vicat method.
3. Practice making pats for time of set tests by the Gillmore method and for soundness tests. The operation should be repeated until specimens of the specified dimensions can be secured with a minimum of effort. Not less than 20 to 30 trials should be made.
4. Practice making 1:3 standard sand mortar briquets until the operation can be carried out smoothly and with a minimum of effort. Check uniformity of operation by weighing the freshly-made briquets. Proper technique has not been attained until the operator can make successive groups of 6 briquets with a variation in weight of less than 20 g. per group.
5. Make fineness determinations on several samples from the same lot of cement (at least ten samples) until successive tests on three samples give results within 1 per cent; for example, residues between 12 and 13 per cent.
6. Make five pats each for time of set tests by the Vicat and Gillmore methods and determine time of set. Between intervals of making observations of time of setting continue practice in the determination of normal

consistency; this test is most important since the quantity of mixing water used in the other tests depends on it.

7. Parallel tests on five different days on five samples of cement should be made by the skilled operator and the operator in training. The samples should be preferably from different lots of cement. The tests should include:

Normal consistency;
Time of setting (Vicat and Gillmore methods);
Soundness;
Standard sand briquets (6 in a batch, 3 each for test at 7 and 28 days);
Fineness.

In the tests for normal consistency, time of setting and fineness, for which the results are obtained as the work proceeds, the difference between the results of the two operators should be not greater than the following:

Normal consistency	0.5 per cent of water
Time of setting	30 minutes
Fineness	1 per cent of fineness

If the operator in training has displayed aptitude in carrying out the tests and his results check those of the skilled operator within the limits stated, he may be considered a skilled operator. However, he should not be permitted to make important tests until the results of the 7 and 28-day strength tests are obtained and his average results for all the specimens made on the five cements on the five different days are shown to check those of the experienced operator within 5 per cent. Attention is again called to the advantages to be gained by frequent interchange of samples for test by different laboratories.

CEMENT TESTS FOR RESEARCH PURPOSES

In making mortar tests of cement for research purposes the methods of mixing, molding, storing, etc., described above should be followed. In order to obtain representative results it is not sufficient in research or other important work to test only three specimens of a kind made from the same batch. At least five and preferably ten specimens should be made for each mix, consistency, age, curing condition, etc., on different days. For example, if it is desired to test specimens of a given mix and consistency at ages of 7 and 28 days, 3 months and 1 year, four specimens may be mixed in a batch, one for test at each of the above ages. Additional batches should be mixed on different days so that five or ten independent specimens may be averaged for the final result. By following this procedure, accidental variations in the tests are distributed so that no one set of specimens is unduly affected.

Experience and tests have shown that the briquet strength is not a satisfactory criterion of the concrete-making properties of cements where wide variations in age, consistency, mix or other variables are present. For research purposes, it is suggested that tests be made on concrete following the methods described in the Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39) of the American Society for Testing Materials.[1]

In research work and other important tests reliance should not be placed on single tests for fineness, normal consistency, time of setting, and soundness. The results should be based on at least duplicate and preferably on triplicate tests.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 143.

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June, 1931

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Revisions and additions.

REPORT OF COMMITTEE C-4

ON

CLAY PIPE

Committee C-4 has held two meetings during the past year, one on February 5, 1932, and the other on April 8, 1932, both in New York City. A third meeting will be held in June at Atlantic City, N. J. in conjunction with the 1932 annual meeting of the Society.

During the past year, the Executive Committee of the Society has created a new standing committee to take charge of concrete pipe to be known as Committee C-13 on Concrete Pipe, and this material has been removed from the jurisdiction of Committee C-4 which will now cover clay pipe only. The name of this committee has been changed to correspond with this change in jurisdiction to Committee C-4 on Clay Pipe.

The reorganization meeting of Committee C-4 was held in New York on February 5, 1932, the reorganized committee consisting of 17 members of whom 8 are classified as producers, 8 as consumers and 1 as general interest. The reorganized committee has appointed three subcommittees, namely, Advisory, Specifications and Nomenclature.

At the meeting held February 5, and also at the meeting held April 8, proposed tentative revisions of the Standard Specifications for Clay Sewer Pipe (C 13 – 24) were unanimously approved and have have been submitted to letter ballot of the committee. The revisions, in general, have been made to conform to current practice and to bring the specifications partly into agreement with the specifications of the Federal Specifications Board. The hydrostatic test requirement has been omitted. Changes in the crushing strength test, principally for purposes of classification, have been made to guard against the inaccuracy of testing machines, and to provide proper bearings for pipe of various sizes. Pipe sizes of 39 and 42 in. nominal diameter have been eliminated to conform to manufacture, and the former maximum absorption requirement has been made an average absorption requirement. Requirements for salt glaze were modified to meet requirements of service. In response to the many requests of industry for a chemical test, a test to determine the resistance of pipe to the action of acids, the use of which is optional, has been added. The revisions have been incorporated in the proposed Tentative Specifications for Clay Sewer Pipe, appended hereto,[1] which are recommended for publication as tentative to supersede when adopted as standard the present Standard Specifications for Clay Sewer Pipe (C 13 – 24).[2]

At the meeting of the committee held at Atlantic City, N. J., June 23, 1932, the present incumbents were reelected for the ensuing term of two years.

The above recommendation has been submitted to letter ballot of the committee with the following results:

Item	Affirmative	Negative	Not Voting
PROPOSED TENTATIVE REVISION OF STANDARD			
Standard Specifications for Clay Sewer Pipe (C 13 – 24)	13	1	3

This report has been submitted to letter ballot of the committee, which consists of 17 members; 14 members returned their ballots, of whom 13 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

G. T. HAMMOND,
Chairman.

E. S. RANKIN,
Secretary.

EDITORIAL NOTE

The proposed revision of the Standard Specifications for Clay Sewer Pipe, in the form of new tentative specifications, was accepted for publication as tentative and appears on page 724.

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[1] See p. 724.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 227.

REPORT OF COMMITTEE C-5

ON

FIRE TESTS OF MATERIALS AND CONSTRUCTION

Since reporting to the Society at the annual meeting in June, 1931, Committee C-5 has continued its study of methods for conduct of fire tests of lumber, applicable to both chemically-treated lumber and to lumber in its natural state; and its work is being extended to include certain related and other subjects as indicated below.

Conditions have not been favorable to periodic meetings during the past twelve months, but a well attended and progressive meeting of the committee was held at New York City on March 17 of this year, contemplating in addition the usual meeting at the time of the annual meeting of the Society at which this report is presented.

A new Subcommittee IV on Fire Tests of Acoustical and Similar Finishes is being organized to prepare standard methods pertaining to the subjects indicated by its title.

A new Subcommittee V on Nomenclature and Definitions has been authorized and will be organized during the coming year.

A new Subcommittee VI on Fire Tests of Scaffolding has also been authorized to prepare standard methods pertaining to the subject indicated by its title.

Committee C-5 has responsibility for only one existing tentative standard, mentioned later in connection with the work of Subcommittee I. In view of the proposed consideration of revisions, Committee C-5 recommends that these specifications be continued as tentative for another year.

The committee feels keenly the loss of its valued member, Mr. Henry Klein, whose death occurred on April 9, in New York City.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Standard Specifications for Fire Tests of Materials and Construction (S. H. Ingberg, chairman).—This subcommittee has given active consideration to the status of the Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 – 26 T),[1] the history of which was briefly summarized in the 1931 annual report of the committee.[2] Since their acceptance by the Society as tentative, various revisions have been proposed.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 761 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 315.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 305 (1931).

Subcommittee I plans during the coming year to review and compile these various suggestions, with intent that Committee C-5 present them to the Sectional Committee on Specifications for Fire Tests of Materials and Construction functioning under the procedure of the American Standards Association.

Subcommittee II on Fire Tests of Lumber (F. P. Cartwright, chairman).—This subcommittee has continued its study of results obtained by various experimenters in the use of the Dunlap Fire Tube, a description of which appears in the Proposed Method of Test for Fire-Retardant Treated Wood published as information in 1930.[1] General experience thus far in the use of this apparatus is favorable, and the subcommittee is considering certain refinements in the text of the method pertaining to details of technique in operation of the apparatus. The subcommittee has further engaged in the study of certain other methods for testing of lumber which have been in use in New York City for some years past and contemplates preparation of standard methods for conduct of these tests. The work of this subcommittee on these latter subjects has been very materially advanced by extensive experimental research work on these older methods of test, conducted by members of the subcommittee.

Subcommittee III on Fire Tests of Wall Opening Protectives (A. H. Beyer, chairman).—This subcommittee has held several active meetings and is progressing efficiently with its work on the preparation of methods for fire tests of doors for use on interior wall openings.

At the meeting of the committee at Atlantic City, N. J., June 22, 1932, the present incumbents were reelected for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 23 members; 21 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

RUDOLPH P. MILLER,
Chairman.

FITZHUGH TAYLOR,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 463 (1930).

REPORT OF COMMITTEE C-6
ON
DRAIN TILE

The effects of the general depression, and particularly of the depression in the agricultural areas, have been such that there has been very little activity in the tile drainage industry. As a result there has been no general demand for any revision or extension of the drain tile standards. No meeting of the committee has been held, the election of officers and the preparation of this report having been handled by correspondence and approved by letter ballot.

The researches sponsored by the committee have been continued and are reported briefly below.

The results of the study of the loads on pipe in wide ditches, by the Iowa Engineering Experiment Station in cooperation with the Clay Products Association, are being published as a Station bulletin. These results furnish criteria for determining the loads on pipe in wide ditches and for determining the field-laboratory strength ratio for pipe so used.

The study of the durability of concrete drain tile in alkali and peat soils, by the Bureau of Agricultural Engineering in cooperation with the University of Minnesota and the Minnesota Department of Drainage and Waters, has been practically completed for alkali soils. The major portion of these results was published in *Public Roads*, May, 1931. All of the data are being prepared for publication in bulletin form.

During the summer of 1931, the Portland Cement Association made the 10-year examination of the field specimens in their study of the durability of concrete in alkaline soils and waters. A report by letter states that the results of this last examination confirm the correctness of the general conclusions given in the Report of the Director of Research, November, 1928, and indicate that properly made and cured concrete is suitable for use in all alkali areas except where the sulfate concentrations are abnormally high.

The election of officers resulted in the reelection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 17 members; 12 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

Anson Marston,
Chairman.

W. J. Schlick,
Secretary.

REPORT OF COMMITTEE C-7

ON

LIME

Committee C-7 on Lime has held but one meeting since the presentation of its report in 1931, and that was during the annual meeting of the Society in June, 1931, in Chicago. The officers of the committee made every effort throughout the year to conduct as much business as possible by correspondence, as it was felt unwise to call upon the members to spend money to attend meetings unless the need was urgent.

No further change in the Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 31 T) is contemplated at the present time; therefore, they should logically be advanced to standard. However, in view of the desire of the Society to effect economy in publication, it has been decided to continue the specifications as tentative for another year when advancement to standard can be made in time for publication in the 1933 Book of Standards.

The committee has approved a further change in the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 31). The change in contemplation is in Section 7 of the specifications relating to soundness of lime. It is proposed to change this section to read as follows: "If the steam has no visible effect on the pat, the sample shall be reported as being 'sound.' If the pat either disintegrates or pops, the sample shall be reported as being 'unsound' and the consignment rejected."

This change was approved in order to strengthen this requirement and to eliminate any uncertainty that might arise in the interpretation of the last sentence of the present Section 7 of the specifications. However, since the committee anticipates making additional changes in this section just as soon as a satisfactory report is available on the results obtained by outside laboratories in checking the new method for determining soundness of limes developed at the U. S. Bureau of Standards, action by the Society on this change will not be asked this year.

That portion of the standard specifications referring to plasticity has also been the subject of considerable thought and discussion during the past year and it is quite possible that some definite changes will be made in the near future. The committee recommends that the tentative revisions of these specifications be continued as tentative for another year.

SUBCOMMITTEE ACTIVITIES

Subcommittee V on Methods of Test of Lime and Lime Products (L. S. Wells, chairman).—The chairman of this subcommittee reports that very satisfactory cooperation has been received from outside laboratories in checking the soundness test for limes which was developed at the Bureau of Standards and that he expects to have an interesting summary ready to present at the June meeting.

Subcommittee X on Hydraulic Lime (W. E. Carson, chairman).—As a result of suggestions made at the last meeting of Committee C-7, the Advisory Committee was authorized to appoint a new Subcommittee X on Hydraulic Lime, whose duties would include initiating a special study of this material and preparing specifications for its use in the construction field. While hydraulic lime is extensively used in European countries, its introduction in this country by American manufacturers is comparatively recent. For this reason and also because hydraulic lime has properties differing somewhat from the recognized quicklime and hydrated lime products, the appointment of the new subcommittee was considered advisable. Mr. W. E. Carson, President of the Riverton Lime Co., was selected as chairman and the work of the subcommittee is now under way.

The election of officers for the ensuing term of two years resulted in the selection of J. R. Withrow, chairman, E. E. Eakins, vice-chairman, F. A. Jones, vice-chairman, and W. V. Brumbaugh, secretary.

This report has been submitted to letter ballot of the committee, which consists of 39 members; 28 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. C. BERRY,
Chairman.

W. V. BRUMBAUGH,
Secretary.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 on Refractories held two meetings during the year; in Cleveland, Ohio, on October 8, 1931, at the time of the fall meeting of the American Refractories Institute, and in Washington, D. C., on February 9, 1932, in conjunction with the annual meeting of the American Ceramic Society.

There was appended to the 1930 report of the committee a Manual for the Interpretation of Refractory Test Data (1929).[1] Since then this Manual has been revised and brought up to date. The committee feels that it is of sufficient value and importance to producers and consumers of refractory materials to warrant the committee underwriting the publication of the Manual with which will be included a complete set of all standard tests pertaining to refractories. This combined pamphlet will be given wide distribution to the trade.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item.

Proposed Tentative Standard.—In view of the fact that increasing quantities of ground and crushed refractory materials are being bought on screen specifications, it was deemed advisable to prepare standard methods of making both wet and dry sieve analyses. The committee accordingly recommends that the proposed Tentative Method of Test for Particle Size of Ground Refractory Materials, prepared by the Subcommittee on Research, be accepted for publication as tentative as appended hereto.[2]

Advancement of Tentative Standard to Standard.—The committee recommends as standard for use in testing refractories the modulus of rupture or flexural strength test described in Sections 8 to 12 of the Standard Methods of Testing Brick (C 67 – 31)[3] developed under the jurisdiction of Committee C-3 on Brick. These methods were tentatively approved by the committee in 1930.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 478 (1930).

[2] See p. 721.—ED.

[3] 1931 Supplement to Book of A.S.T.M. Standards, p. 65.

Proposed Tentative Revision of Standard.—The committee recommends for publication as a tentative revision the addition of cones Nos. 36, 37 and 38 to the table of heating rates in the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31),[1] as follows:

Section 5.—Add to the table of heating rates following Paragraph (*a*) the following requirements for cones Nos. 36, 37 and 38, not heretofore provided for:

Time interval to cone 36	10 minutes
" " " " 37	4 "
" " " " 38	6 "

Advancement to Standard of Tentative Revisions of Standards.—The committee recommends the advancement to standard of the tentative revisions proposed in 1931[2] in Section 5 of the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 20).[3] These revisions which substitute water for kerosine for determining porosity by the suspension method, also provide for boiling the sample instead of a long immersion under vacuum at room temperature, and furnish data for calculating absorption.

The committee also recommends the advancement to standard of the tentative revision, proposed in 1931,[4] in Section 2 only, which covers the description of the preparation of the sample in the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31).[3]

The recommendations appearing in this report affecting standards and tentative standards have been submitted to letter ballot of the committee with the results shown in Table I.

RESEARCH ACTIVITIES OF SUBCOMMITTEES

The Subcommittee on Research has been active in studying the effect of the rate of drying as well as the rate of heating in the draw trial test for measuring clay shrinkage. This work will be pursued in some university laboratories. A method for the determination of alkalies in refractories by a distillation method is also being considered. This subcommittee is also studying high-temperature cements, with the expectation that their performance in service may be estimated from laboratory tests.

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 69.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1054 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 920.

[3] The advancement to standard of these tentative revisions was deferred until the 1933 annual meeting, see Editorial Note, p. 356.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1056 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 922.

Standard Samples of Refractory Materials.—The cooperating analysts have completed their work on the proposed standard sample of silica brick and a provisional certificate will be issued shortly by the U. S. Bureau of Standards. The work on magnesite and chrome will be completed before June 1, 1932.

Survey of Furnaces Used to Perform the Load Test.—The Section on Load Test found that the following were the principal reasons for various laboratories not adhering to the furnace specified in the Standard Methods of Test for Refractory Materials Under Load at High Temperatures (C 16 – 20):

1. Limited space available in the laboratory;
2. Better temperature control and distribution;
3. Desire to test more than two bricks at one time.

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Method of Test for Particle Size of Ground Refractory Materials:			
Method for Dry Screen Analysis	18	1	5
Method for Wet Screen Analysis	17	2	5
Standard Sieve Series	18	2	4
II. TENTATIVE REVISION OF STANDARD			
Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31)	31	0	0
III. APPROVAL OF METHODS AS STANDARD			
Methods of Testing Brick for Flexure (Modulus of Rupture) (C 67 – 31)	27	3	1
IV. ADVANCEMENT TO STANDARD OF TENTATIVE REVISIONS OF STANDARDS			
Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 20)	31	0	0
Method of Test for Softening Point of Fire-Clay Brick (C 24 – 31) (Section 2, only)	31	0	0

It was recommended that the present test be modified to state that "Any suitable furnace and loading device may be used provided the test conditions specified are obtained" and that the present specified apparatus be considered an acceptable design, but not mandatory. However, subsequent discussion brought out that the same brand of brick tested in different laboratories with various furnaces meeting the specified conditions will frequently show variations of 200 to 300 per cent in the results obtained. It will be necessary to give further study to this subject and an effort made to control the variables not mentioned in the present Standard Method C 16.

Measurement of Warpage in Refractories.—The Section on Precision and Tolerance has approved the principle of the warpage meter developed at the Mellon Institute for measuring the warpage of refractories, but before adopting the instrument additional studies will be made as to the proper materials to use in its construction, the best method of manufacture, and approximate cost.

As noted earlier in the report, revisions and additions have also been made to the Manual for the Interpretation of Refractory Test Data in order to bring it up to date.

Investigation of the P. C. E. Test.—The Section on Temperature has recommended that the present heating rate of 150° C. per hour be extended to include cones Nos. 36, 37 and 38. So far no agreement has been reached on the design of a standard P. C. E. furnace. A study is being made on the determination of the Pyrometric Cone Equivalent of materials with values below cone No. 20. A study is also being conducted on refractory cements containing added fluxes to determine means of preventing the segregation of soluble salts on the surface of the cones and in the cone plaque. Preliminary calcination of the cements seems to overcome this difficulty.

In view of the long gap between cones Nos. 32 and 33 it has been suggested that a new cone be made to fill in, such a cone being called cone No. 32*A*. This is being taken up with the Standard Pyrometric Cone Co.

Measuring Heat Transmission of Refractories.—Considerable work is being done on thermal conductivity by Mr. R. H. Heilman, chairman of the Section on Heat Transmission. In addition to laboratory tests, large scale experiments with industrial equipment are also being considered. The Advisory Committee of Committee C-8 has approved the idea of the Section on Heat Transmission taking charge of the study of all other physical characteristics of refractory insulating materials. The properties which may be of special interest are the following:

1. Cold crushing strength
2. Transverse strength
3. Shrinkage
4. Impact resistance
5. Hardness
6. Crushing strength under heat
7. Expansion under heat.

In some cases it may be possible to use the present tests developed by Committee C-8 for these materials, but it is conceivable that in some instances entirely new standards may be required.

At the meeting of Committee C-8 held in Washington, D. C., on February 9, 1931, the committee reelected Mr. G. A. Bole as chairman and elected Mr. C. E. Bales as secretary to direct the work of the committee for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 32 members; 32 members returned their ballots, of whom 28 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

G. A. BOLE,
Chairman.

C. E. BALES,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Test for Particle Size of Ground Refractory Materials was accepted for publication as tentative and appears on page 721.

The proposed revision of the Standard Method of Test for Softening Point of Fire-Clay Brick was accepted for publication as tentative and appears on page 998.

The proposed advancement to standard of the tentative revisions of the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials and of Section 2 of the Method of Test for Softening Point of Fire-Clay Brick, as recommended in the report, was referred at the annual meeting to the Executive Committee with power. The advancement to standard of these tentative revisions has been deferred until the 1933 annual meeting. The revisions have accordingly been continued as tentative and appear on pages 997 and 998.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES

Committee C-9 on Concrete and Concrete Aggregates has continued active work during the past year on the many projects before it. Adverse economic conditions, however, have delayed the completion of some of the work under consideration so that much that normally would be included with this report must be held over for another year. The failure to complete many of the projects planned for this year may be accounted for, principally, by the omission of the usual fall meeting. In addition to the meeting held during the 1931 annual meeting, only one meeting has been held during the year, on March 8 in Cleveland, Ohio, in connection with the Spring Group Meetings of A.S.T.M. Committees.

At a meeting of the committee held during the annual meeting of the Society at Chicago, Ill., in June, 1931, Subcommittee IX on Specifications and Methods of Tests of Aggregates presented proposed Tentative Methods of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 – 31 T) and Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (C 89 – 31 T) which were approved by submission to Committee E-10 on Standards. The proposed tentative methods were subsequently presented to the Society through Committee E-10 and were accepted for publication as tentative on August 6, 1931.[1] The new tentative standards were published in the 1931 *Proceedings*.[2]

The material offered for publication as a part of this year's report consists of recommended revisions in four standards and three tentative standards sponsored by Committee C-9, and a suggested procedure for testing concrete and aggregates by freezing and thawing. The revisions in standards result from experience with their use and, for the most part, are for the purpose of clarifying and amplifying statements of procedure and of bringing them into conformity with similar standards of other organizations. The revisions involve no fundamental changes in procedure. Those recommended for adoption by the Society are summarized and discussed later in the report.

The outline of procedure for testing concrete and concrete aggregates by freezing and thawing, which appears as an appendix to this report, is the joint contribution of Subcommittees IX on

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[1] In submitting the methods to Committee E-10, the committee reported results of the letter ballot vote as follows: 41 members returned their ballots, of whom 37 voted affirmatively, 3 negatively and 1 member refrained from voting.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 769 to 776 (1931).

Specifications and Methods of Tests of Aggregates and XVII on Conditions Affecting Durability of Concrete in Structures. It is presented at this time because of the importance of the subject and with the hope that this summary of the experience of members of the committee will be of assistance in guiding further investigations along these lines. Those most active in the outline of this procedure recognize that considerable revision should be made in it before offering it to Committee C-9 for recommendation as a tentative method of test of the Society.

As indicated earlier in this report, each of the eighteen subcommittees of Committee C-9 has continued its consideration of the several projects before it. However, it does not seem necessary to include comments on the status of uncompleted work in this brief statement. It should suffice to say that a number of reports on important subjects have been distributed in the committee and that these will be considered for publication with next year's report.

Mention should be made of one project which only the limitations of time have prevented from being considered for report at this meeting. The recently organized Subcommittee XVIII on Ready-Mixed Concrete has prepared specifications covering the materials, proportioning, mixing, delivery, inspection, testing and acceptance of ready-mixed concrete for all purposes. These specifications have been distributed to the committee and to others interested and competent to comment. An unusual amount of interest has been displayed in the preliminary draft of the specifications and a large volume of helpful suggestions has been received. It is expected to submit a revised draft at the next meeting of Committee C-9 for consideration as a tentative standard.

A number of changes in the personnel of the committee have been made and will be recorded in the Year Book. The committee welcomes several new members whose knowledge and experience will enable them to be valuable additions in the work of the committee. The loss sustained by reason of the passing of Willis A. Slater is keenly felt; his place cannot be completely filled.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Revisions of Standards.—The committee recommends that revisions, as given in detail below, in the following standards be accepted for publication as tentative:

Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (*C 31 – 31*):[1]

Section 5 (*b*).—This section, describing the method of molding test specimens, needs clarification in certain respects. For example, a strict interpretation of the present wording would permit of placing concrete in the standard 6 by 12-in. cylinder mold in either three or four layers and of puddling it either 75 or 100 times. The committee recommends, therefore, that Paragraph (*b*) of this section be changed from its present form: namely,

> (*b*) The test specimens shall be molded by placing the concrete in the mold in layers 3 to 4 in. in thickness. Each layer shall be puddled with 25 strokes with a ⅝-in. rod 24 in. in length bullet-pointed at the lower end. After puddling the top layer, the surface concrete shall be struck off with a trowel and covered with the top cover plate which may later be used in capping the test specimen.

to read as follows:

> (*b*) The test specimens shall be molded by placing the fresh concrete in the mold in three layers, each approximately one-third the volume of the mold. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mold as the concrete slides from it in order to insure a symmetrical distribution of concrete within the mold. Each layer shall be rodded with 25 strokes of a ⅝-in. rod 24 in. in length, bullet-pointed at the lower end. The strokes shall be distributed in a uniform manner over the cross-section of the mold and shall penetrate into the underlying layer. The bottom layer shall be rodded throughout its depth. After the top layer has been rodded the surface of the concrete shall be struck off with a trowel and covered with a glass plate at least ¼ in. in thickness or with a machined metal plate, which may be used later in capping the test specimens.

Standard Methods of Making Compression Tests of Concrete (*C 39 – 27*):[2]

Section 13.—This standard includes a section on molding test specimens essentially the same as that in Method C 31 – 31, mentioned above, although the wording is slightly different. In order to make the phraseology uniform in the two similar standards and to eliminate ambiguities, such as those referred to, the committee recommends that this section be changed from its present form: namely,

> 13. Concrete test specimens shall be molded by placing the fresh concrete in the mold in layers 3 to 4 in. in thickness. Each layer shall be puddled with 25 strokes with a ⅝-in. rod 24 in. in length, bullet-pointed at the lower end. After the top layer has been puddled, the surplus concrete shall be struck off with a trowel, and the mold covered with a piece of plate glass at least ¼ in. in thickness or a machined metal plate which will be used later in capping the test specimen.

to read the same as proposed for the revision of Section 5(*b*) in Method C 31 – 31 given above.

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 58.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 143.

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 27):[1]

This standard differs in several more or less minor respects from the standard procedure for the same test adopted by the American Association of State Highway Officials. The committee has considered the several discrepancies and recommends that this method be revised to conform with that of the A.A.S.H.O. in the following respects:

Sections 3 (b) and 4.—Add a footnote reference after the term "sodium hydroxide" to refer to the following footnote:

> Where chemically pure sodium hydroxide is not available, commercial soda lye may be used.

New Section.—Add a new Section 6 to read as follows:

> 6. In lieu of the method described in Section 5 (*a*), the color of the clear liquid above the sand may be compared with the colors given in Fig. 1 (Plate I).[2]

Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24):[3]

In order to clarify the purpose of this standard, the committee recommends the addition of the following paragraph as a footnote:

> This method is intended primarily for use in connection with the sieve analysis of either coarse aggregates or mixtures of fine and coarse aggregates for various types of construction, including concrete, when the sizes larger than No. 4 are specified on the basis of sieves with square openings.

Proposed Revisions of Tentative Standards.—The committee recommends that the following tentative methods be revised, as given in detail below, and continued as tentative:

Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar (C 87 - 31 T):[4]

The committee has learned that some confusion has resulted in the use of this method on account of the fact that in Section 2 the quantity of mixing water is expressed as a ratio by volume, while the testing procedure makes it more convenient to express quantities of all materials in terms of weight. It is recommended, therefore, that the water-cement ratio of 0.9 by volume be changed to the equivalent in terms of weight. It has also been pointed out to the committee that some inaccuracies in results of this test have come from failure to take account properly of the water absorbed by the aggregate.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 154.

[2] This figure is not included in the present preprint. The color plate referred to appears in *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part I, p. 322 (1919).

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 155.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 767 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 261.

In order to guard against this source of error, the committee recommends the following changes in Section 2:

Section 2.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> 2. Cement and water in quantities which will give a water-cement ratio of [0.9] *0.6 by weight* shall be placed in an appropriate vessel and the cement permitted to absorb water for 1 minute. The materials shall then be mixed with a spoon into a smooth paste. *Saturated and surface-dried* sand from a sample of known weight shall [then] be beaten into the mixture until the material appears to be of the desired consistency (flow 100 ± 5). The mixing shall be continued for one-half minute, and a determination of the flow made.

Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 - 31 T):[1]

In order to clarify the wording of this test method in certain instances and to make it conform to the proposed method outlined by the American Association of State Highway Officials for the same test, the following revisions are recommended:

Section 2.—Change Note (*2*) following this section to read as follows by the addition of the italicized words:

> (*2*) Each sample placed in a container with a wire mesh bottom and immersed in a vat containing the sodium sulfate solution. Care should be taken to prevent loss by flotation if uncovered containers are submerged. *If nesting sieves are used precaution should be taken to prevent loss of material from one sieve to another.*

Section 7.—Add to the table of sieve sizes the following:

Retained on Sieve No. 100, passing Sieve No. 50.

Section 8.—Change the reference to sieve "No. 50" to read "No. 100."

Section 12 (*a*).—Change from its present form: namely,

> (*a*) After the completion of the final cycle and after the sample has cooled, the sodium sulfate shall be washed from the sample by means of warm water. This shall be done by soaking the sample in fresh, clean, warm water for approximately one hour, decanting the liquid and repeating this operation *at least* four times. Materials of high absorption may require a greater number of washings.

to read as follows:

> (*a*) After the completion of the final cycle and after the sample has cooled, the sample shall be washed free from sodium sulfate as determined by the reaction of the wash water with barium chloride ($BaCl_2$).

New Section.—Add a new Section 14 covering the recording of test data to read as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 769 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 263.

14. Table I, shown with test values inserted for purpose of illustration, is a suggested form for recording test data.

TABLE I.—FORM FOR RECORDING TEST DATA ON SODIUM SULFATE SOUNDNESS TEST OF FINE AGGREGATES. (TEST VALUES SHOWN ARE FOR PURPOSE OF ILLUSTRATION.)

Sieve Size		Grading of Original Sample, per cent	(a) Weight of of Test Fractions Before Test, g.	(b) Percentage Passing Finer Sieve After Test (Actual per cent Loss)	(c) Weighted Average (Corrected per cent Loss)
Passing	Retained on				
No. 100		5.0	...	0[a]	0
No. 50	No. 100	6.4	100	3.5	0.22
No. 30	No. 50	26.0	100	4.2	1.09
No. 16	No. 30	25.2	100	4.8	1.21
No. 8	No. 16	17.0	100	8.0	1.36
No. 4	No. 8	10.8	100	11.2	1.21
$\frac{3}{8}$ in.	No. 4	9.6	100	7.1	0.68
Totals		100.0	600		5.77

[a] Not tested; assumed to be zero.

Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (C 89 - 31 T):[1]

Make the same change in Section 14(*a*) of this method as is recommended above in Section 12(*a*) of Method C 88 - 31 T.

TABLE II.—ILLUSTRATED FORM FOR RECORDING TEST DATA ON SODIUM SULFATE SOUNDNESS TEST OF COARSE AGGREGATES. (TEST VALUES SHOWN ARE FOR PURPOSE OF ILLUSTRATION.)

Sieve Size		Grading of of Original Sample, per cent	(a) Weight of of Test Fractions Before Test, g.	(b) Percentage Passing Finer Sieve After Test (Actual per cent Loss)	(c) Weighted Average (Corrected per cent Loss)
Passing	Retained on				
$2\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	20.0	3000[a]	4.8	0.96
$1\frac{1}{2}$ in.	$\frac{3}{4}$ in.	45.0	1500[a]	8.0	3.60
$\frac{3}{4}$ in.	$\frac{3}{8}$ in.	23.0	300[a]	9.6	2.20
$\frac{3}{8}$ in.	No. 4	12.0	100[a]	11.2	1.34
Totals		100.0	4900		8.10

Minimum amounts; larger samples may be used.

New Section.—Add a new Section 16 covering the recording of test data to read as follows:

16. Table I (the accompanying Table II), shown with test values inserted for purpose of illustration, is a suggested form for recording test data.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 773 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 267.

In accordance with the Regulations of the Society, officers were elected at the meeting of the committee held on June 23. The following were elected:

Chairman, R. W. Crum;
Vice-Chairman, Stanton Walker;
Secretary, R. R. Litehiser;
Chairman of Finance Committee, F. W. Kelley;
Member-at-Large of the Executive Committee, A. N. Talbot.

The recommendations outlined above have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE REVISIONS OF STANDARDS			
Standard Method of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 - 31)	42	1	1
Standard Methods of Making Compression Tests of Concrete (C 39 - 27)	41	1	1
Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 27)	39	4	2
Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 24)	41	1	3
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar (C 87 - 31 T)	38	2	5
Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 - 31 T)	36	1	6
Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (C 89 - 31 T)	35	1	7

This report has been submitted to letter ballot of the committee, which consists of 55 members; 42 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

STANTON WALKER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field, of Making Compression Tests of Concrete, of Test for Organic Impurities in Sands for Concrete and of Test for Sieve Analysis of Aggregates for Concrete were accepted for publication as tentative and appear on pages 1000 to 1002.

The proposed revisions of the Tentative Methods of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar and for Soundness of Coarse Aggregates by Use of Sodium Sulfate were accepted. The methods in their revised form appear on pages 711 and 717, respectively.

The proposed revisions of the Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate, with additional changes proposed on the floor of the annual meeting, see Summary of Proceedings, page 29, were accepted. The methods in their revised form appear on page 713.

APPENDIX

PROPOSED METHOD OF TESTING CONCRETE AND CONCRETE AGGREGATES BY FREEZING AND THAWING[1]

SUBMITTED BY C. H. SCHOLER AND A. E. STODDARD

1. *Apparatus.*—The equipment used shall be a mechanical refrigerator which, for the temperature of test, condition of exposure, and size of specimen, will lower the temperature in all parts of the specimen below 24° F. in not more than four hours.

2. *Test Specimens*: (*a*) *Concrete.*—The test specimens of concrete shall be approximately cubical or cylindrical in shape with the least dimension not less than three times the size of the largest aggregates. Test specimens of hardened concrete shall be obtained in accordance with the Standard Methods of Securing Specimens of Hardened Concrete from the Structure (A.S.T.M. Designation: C 42) of the American Society for Testing Materials.[2]

The age of concrete specimens at the time of testing should be not less than 90 days for concrete using normal portland cements, and not less than 60 days for concrete using high-early-strength cements.

(*b*) *Aggregates.*—Test specimens of aggregate shall consist of material graded to represent truly the material. When samples of stone are obtained from the quarry face they shall be broken to fragments approximately cubical, and shall be as free as possible from loose chips or incipient fractures produced in the preparation of the specimens.

Approximately 2000 g. retained on a No. 4 sieve shall be used as a test specimen.

3. *Preparation of Specimens.*—Test specimens of both concrete and aggregates shall be thoroughly saturated by immersion in water at 70° F. for 24 hours before freezing.

4. *Conditions of Freezing.*—Concrete specimens shall be immersed in water during freezing. Aggregate specimens shall be placed in water of a depth of $\frac{1}{4}$ in. during freezing.

5. *Conditions for Thawing.*—Both concrete and aggregate specimens shall be thawed by immersion in water at a temperature between 60 and 100° F.

6. *Duration of Test.*—One cycle shall consist of one complete freezing and one thawing of the test specimens. The number of cycles specified for test necessarily will depend upon the purpose for which the material or concrete is intended and the severity of the exposure.

7. *Measurement of Disintegration.*—At the completion of the test the extent and character of the disintegration shall be determined by visual examination. Quantitative results for aggregates may be obtained by weighing the material retained on the No. 4 sieve in a saturated surface-dried condition and comparing this weight with the corresponding weight of the sample before the first freezing.

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[1] Criticisms of this proposed method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Bureau of Tests, Ohio State Highway Department, Columbus, Ohio.

This proposed method of testing concrete and concrete aggregates by freezing and thawing is presented at this time because of the importance of the subject and with the hope that this summary of the experience of members of the committee will be of assistance in guiding further investigations along these lines. Those most active in the preparation of this procedure recognize that the details of this test should be considerably amplified and clarified before it is offered to the committee for recommendation as a tentative method.

[2] 1931 Supplement to Book of A.S.T.M. Standards, p. 63.

COMMENTS ON PROPOSED METHOD

The committee believes that this procedure is set forth in as full detail as is warranted by present knowledge of the application of tests for durability of aggregates and concrete.

In connection with this proposed method of making freezing-and-thawing tests of concrete and concrete aggregates the following comments may prove of interest:

1. The type of apparatus selected by any operator will be influenced by the scope of operations contemplated and the number of specimens to be examined. Where only aggregates are to be tested, the specimens may be frozen in trays directly in contact with metal shelves or fins of the refrigerating unit. For larger installations and for concrete specimens, it will be necessary to surround the specimen containers with an anti-freezing liquid which will conduct the heat to the cooling solution.

2. Several advantages accrue through the freezing of concrete specimens immersed. A thorough saturation of the concrete is obtained and the possibility of shock through suddenly coming in contact with excessively high or low temperatures is eliminated and it is believed that, in general, the rate of deterioration is somewhat faster than when the concrete is frozen saturated, but in air. Slight variations in the rate of freezing with a concrete exposed to the air in a saturated condition may cause considerable variation in the actual water content of the surface of the concrete and a consequent variation in the severity of the test. If the concrete is immersed in water, no such variation is possible and it is believed that slight variations in the rate of freezing are of no significance. Since the amount of energy consumed in freezing the concrete and the water is increased very rapidly with increased quantity of water, it is recommended that the concrete be placed in close-fitting metal containers of rather thin metal. If the walls of the containers are very heavy, excessive pressure may result from the ice developed during freezing.

3. To secure the rate of freezing specified, the test specimens should be immersed in water in close-fitting, thin metal containers which are in turn immersed in alcohol or brine solution. A temperature of $-15°$ F. will freeze a 6-in. concrete test cylinder exposed in this manner in about one hour to one hour and twenty minutes, depending upon the amount of water surrounding the cylinder. If the temperature of the brine or alcohol solution can be below $-15°$ F. this should allow ample time for the freezing of 6 by 12-in. specimens. In case there is any doubt as to the amount of time required to produce freezing of concrete on the inside of the specimen, indicating resistance thermometers should be embedded in the center of the block and an actual determination made.

4. In cutting specimens with a saw, much care should be exercised to prevent local heating of the aggregate coming in contact with the saw; this is particularly important with the highly siliceous materials. In observing the results of tests, care should be exercised to distinguish between loss due to local overheating and losses occasioned by the freezing-and-thawing test.

5. The resistance to freezing and thawing appears to increase with age over a considerable period of time. Under natural conditions it never would be possible for concrete to be subjected to any appreciable number of freezing-and-thawing cycles until after ample time had elapsed for the thorough curing of the concrete. For this reason relative resistance of concretes at early ages might not be indicative, necessarily, of their resistance after a year or more of aging.

6. If the concrete test specimens are frozen in close-fitting metal containers, thawing occurs very rapidly and excessively high temperatures of thawing water are not required. The possibility of shock due to immersing the test specimens at a temperature below 0° F. in hot water adds another unknown element and it is not believed necessary or desirable to introduce this variable.

7. It is not recommended that the freezing-and-thawing test of an aggregate be used as the sole basis of its rejection unless this test definitely identifies this material as being material that gives unsatisfactory service in concrete. If there is any question as to the suitability of an aggregate from the viewpoint of its resistance to freezing and thawing, tests should be made upon concrete in which the aggregate is incorporated, and its action under these conditions used as a basis for acceptance or rejection.

8. It has been observed that aggregate may contain a considerable amount of material which disintegrates to a pulp in this test, and that concrete containing this material may not be particularly injured by the breaking down of small portions of the aggregate in this manner. Even smaller portions of aggregate than above mentioned which disintegrate by checking or splitting of the pieces with considerable volume change are very objectionable and may result in the almost complete disintegration of the concrete. Much research work will be required before general methods for measuring the loss or extent of distintegration of either aggregate or concrete can be set forth.

REPORT OF COMMITTEE C-11

ON

GYPSUM

Following its usual custom, Committee C-11 on Gypsum held its fall and spring meetings at the U. S. Bureau of Standards, Washington, D. C. The fall meeting was held on November 20, 1931, and the spring meeting on March 24, 1932. A third meeting will be held at Atlantic City, N. J. in conjunction with the annual meeting of the Society.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Gypsum for Various Uses (H. J. Brown, chairman).—This subcommittee, with the cooperation of Mr. P. S. Roller of the Non-Metallic Minerals Experiment Station of the U. S. Bureau of Mines, is continuing its investigation on the fundamental factors in the retardation of portland cement by calcium sulfate.

Subcommittee II on Gypsum Plasters (J. M. Porter, chairman).—This subcommittee has been concentrating its efforts on the use of the modified Vicat apparatus for the determination of testing consistency of sanded gypsum plaster and gypsum wood-fiber plaster. It has been successful in its efforts and has recommended that the modified Vicat apparatus be adopted as the standard method of determining consistency of these plasters.

Subcommittee IV on Testing Methods (C. K. Roos, chairman).—This subcommittee has been very active in reviewing the Standard Methods of Testing Gypsum and Gypsum Products (C 26 – 30)[1] and has prepared numerous proposed changes in these methods.

RECOMMENDATIONS AFFECTING STANDARDS

The following recommendations are made relative to the standards under the jurisdiction of the committee:

Standard Specifications for Gypsum Partition Tile or Block (*C 52 – 27*).[2]—In view of the fact that a small percentage of free water in tile will appreciably reduce its compressive strength it is proposed that the first sentence of Section 13 (*b*) be revised to include a maximum relative humidity condition. For the same reason it is recommended that the last sentence of Section 13 (*c*) be revised to require that samples be tested in accordance with the requirements of Paragraph

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 125.

[2] *Ibid.*, p. 120.

(*b*) of this section. The committee accordingly recommends the following changes in these specifications for publication as tentative:

Section 13.—Change the first sentence of Paragraph (*b*) from its present form: namely,

> The test specimens shall be dried to constant weight at a temperature not exceeding 110° F. (43° C.), until two successive weighings of the same specimen do not show a variation in excess of 0.5 per cent.

to read as follows:

> The test specimens shall be dried at a temperature of not less than 21.1° C. (70° F.) nor more than 37.8° C. (100° F.) in an atmosphere of not more than 50 per cent relative humidity. The specimen shall be weighed at 1-day intervals until constant weight is attained.

Change Paragraph (*c*) from its present form: namely,

> (*c*) The tile or block shall be tested in the position in which they are designed to be used and shall be bedded on and capped with a felt gasket not less than ⅛ in. nor more than ¼ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test samples may be suitably bedded and capped with neat gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When neat gypsum mortar is used for bedding and capping, the test may be conducted after the mortar has set, but not sooner than twenty-four hours after the sample has been capped.

to read as follows:

> (*c*) The tile or block shall be tested in the position in which it is designed to be used, and shall be bedded on and capped with a felt pad not less than ⅛ in. nor more than ¼ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test samples may be suitably capped with calcined gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When calcined gypsum is used for capping, the test may be conducted after the capping has set, and the specimen tile dried to constant weight in accordance with Paragraph (*b*).

Section 14.—This section deals with the method of testing to determine the modulus of rupture of gypsum tile or block but there are no minimum modulus of rupture requirements given in the specifications. It is felt that since a gypsum partition tile is a non-load-bearing unit and is erected on edge that the compressive strength requirement is adequate. The committee therefore recommends that Section 14 be omitted from the specifications.

Standard Specifications for Gypsum Plasters (C 28 – 30)[1]; *Standard Specifications for Gypsum Molding Plaster (C 59 – 30)*[2]; *Standard Specifications for Gypsum Pottery Plaster (C 60 – 30).*[3]—At the end of these several specifications is an explanatory note concerning the water used for mixing gypsum plaster. It was thought that this might be interpreted as permitting ordinary city water to be used for testing gypsum plasters. The committee felt that this should be clarified and accordingly recommends that the note be changed to read as follows, this change to be considered as editorial:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 105.

[2] *Ibid.*, p. 109.

[3] *Ibid.*, p. 111.

> NOTE.—The water used for mixing gypsum plasters shall be clean and free from excessive amounts of mineral and organic substances. Distilled water shall be used for conducting all tests.

Standard Methods of Testing Gypsum and Gypsum Products (C 26 - 30).[1]—Subcommittee IV was delegated the responsibility of reviewing the test methods for gypsum products and their relation to the various standard specifications and standard practice. This study revealed several minor inconsistencies and several improvements in testing procedure. Important changes in testing methods were suggested only after a thorough series of tests had been conducted which demonstrated the advisability of making the changes. These revisions have been incorporated in the proposed Tentative Methods of Testing Gypsum and Gypsum Products, appended hereto,[2] which the committee recommends for publication as a tentative revision of the present Standard Methods C 26 - 30, to subsequently supersede the present methods when adopted as standard.

The recommendations appearing in this report have been submitted to letter ballot of the committee, with the following results:

Items	Affirmative	Negative	Not Voting
PROPOSED TENTATIVE REVISIONS OF STANDARDS			
Standard Specifications for Gypsum Partition Tile or Block (C 52 - 27)...............	25	0	4
Standard Methods of Testing Gypsum and Gypsum Products (C 26 - 30).............	28	0	1

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 30 members; 29 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. SCHWEIM, J. W. GINDER,
Secretary. *Chairman.*

EDITORIAL NOTE

The proposed revision of the Standard Specifications for Gypsum Partition Tile or Block was accepted for publication as tentative and appears on page 995.

The proposed revision of the Standard Methods of Testing Gypsum and Gypsum Products, in the form of new tentative methods, was accepted for publication as tentative and appears on page 700.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 125.

[2] See p. 700.—ED.

REPORT OF COMMITTEE D-1
ON
PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held a two-day meeting at the U. S. Bureau of Standards, Washington, D. C., on April 4 and 5, 1932. The first day and the morning of the second day were devoted to subcommittee meetings and the meeting of the main committee was held on the afternoon of April 5.

Several of the subcommittees have been very active and there is a lively interest in many of the lines of work being carried on by the committee.

Since the last annual meeting 14 new members have been elected and 13 resignations have been accepted, leaving a total membership of 168.

The work of the active subcommittees during the past year has resulted in the committee making the following recommendations to be acted upon at the annual meeting:

I. Four new tentative specifications and one new tentative method of test are being submitted;

II. Revisions are proposed as tentative in one standard specification and nine standard methods of test;

III. Revisions of one tentative specification and one tentative method of test are proposed.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

In this report, recommendations affecting standards and tentative standards are noted in brief form below together with the results of the letter ballot. These recommendations are explained in greater detail in the reports of the subcommittees which are directly responsible for them.

I. *Proposed Tentative Standards.*—The committee submits for publication as tentative, the following four new specifications and one new method of test as appended hereto:

Tentative Specifications for Ethylene Glycol Mono Butyl Ether,[1] recommended by Subcommittee XXV;

Tentative Specifications for Ethylene Glycol Mono Ethyl Ether,[2] recommended by Subcommittee XXV;

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[1] See p. 738.—Ed.

[2] See p. 739.—Ed.

Tentative Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent grade),[1] recommended by Subcommittee XXV;

Tentative Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent grade),[2] recommended by Subcommittee XXV.

Tentative Method of Test for Comparative Hiding Power of Paints,[3] recommended by Subcommittee VIII;

II. *Proposed Tentative Revisions of Standards.*—The committee recommends that the revisions, given in detail in the reports of Subcommittees VIII and XV, in the following standard specifications and the nine standard methods of test be accepted for publication as tentative:

Standard Specifications for Basic Carbonate White Lead (D 81 - 31);

Standard Methods of Routine Analysis of White Pigments (D 34 - 30);

Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 29);

Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 29);

Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 - 27);

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 27);

Standard Methods of Routine Analysis of Titanium Pigments (D 186 - 29);

Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 - 29);

Standard Method of Routine Analysis of Dry Mercuric Oxide (D 284 - 29);

Standard Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 - 31).

III. *Proposed Revisions of Tentative Standards.*—The committee recommends that the following tentative specifications and tentative methods of test be revised as given in detail in the reports of the respective subcommittees and continued as tentative:

Tentative Specifications for Glazier's Putty (D 317 - 30 T), as proposed by Subcommittee XV;

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[1] See p. 740.—ED. [2] See p. 741.—ED. [3] See p. 745.—ED.

Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 31 T), as proposed by Subcommittee XXV.

IV. *Tentative Standards Continued as Tentative.*—In addition to the recommendations affecting the tentative standards mentioned in this report, there are a number of additional tentative standards under the jurisdiction of the committee not specifically mentioned in this report or in the subcommittee reports. It is recommended that these tentative standards be continued for another year as tentative without revision.

The above recommendations have been submitted to letter ballot of the committee, which consists of 168 members; 66 members returned their ballots. The analysis of the vote of the committee is given in the following table:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Specifications for Ethylene Glycol Mono Butyl Ether	42	0	24
Specifications for Ethylene Glycol Mono Ethyl Ether	42	0	24
Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent Grade)	42	0	24
Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent Grade)	42	0	24
Method of Test for Comparative Hiding Power of Paints	50	3	13
II. PROPOSED TENTATIVE REVISIONS OF EXISTING STANDARDS			
Specifications for Basic Carbonate White Lead (D 81 – 31)	52	0	14
Methods of Routine Analysis of White Pigments (D 34 – 30)	50	2	14
Methods of Routine Analysis of White Linseed Oil Paints (D 215 – 29)	50	2	14
Methods of Routine Analysis of Dry Red Lead (D 49 – 29)	48	0	18
Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese (D 50 – 27)	48	0	18
Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 27)	48	0	18
Methods of Routine Analysis of Titanium Pigments (D 186 – 29)	49	0	17
Method of Routine Analysis of Dry Cuprous Oxide (D 283 – 29)	46	0	20
Method of Routine Analysis of Dry Mercuric Oxide (D 284 – 29)	46	0	20
Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 31)	50	0	16
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Glazier's Putty (D 317 – 30 T)	44	0	22
Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 31 T)	42	1	23

ACTIVITIES OF SUBCOMMITTEES

Appended hereto are reports of the following subcommittees:

Subcommittee VII on Accelerated Tests for Protective Coatings;

Subcommittee VIII on Methods of Analysis of Paint Materials;

Subcommittee XV on Specifications for Pigments, Dry and in Oil, when Marketed in that Form; and

Subcommittee XXV on Cellulose Ester Coatings.

In addition to the subcommittee reports appended, the activities of other subcommittees are reported as follows:

Subcommittee V on Linseed Oil (R. D. Bonney, chairman).—This subcommittee has not been carrying on any definite program of work during the past year, but because of the abnormal linseed oil which has resulted from recent crops of flaxseed, it was thought proper to make the following comment: "Due to abnormal conditions in Argentina, the 1931 crop of Argentina flaxseed produced linseed oil with an excessively high acid number. A large proportion of the oil crushed from this seed had an acid number higher than the maximum under the A.S.T.M. specifications. However, in view of the fact that this was an abnormal condition and, that oil from the current crop of seed has returned to a normal range of acidity, it is not recommended that any change be made in the specifications."

Subcommittee XII on Turpentine (F. P. Veitch, chairman).—This subcommittee has been active on a proposed revision of the Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 – 26) in an effort to broaden it so that sulfate wood turpentine can be included. Two reports were made to the committee representing the majority and minority opinions in the subcommittee, and as it was apparent that no concerted action could be taken at this time the matter was referred back to the subcommittee for further consideration. Members of the Society who are interested in this subject are requested to get in touch with the chairman of this subcommittee.

Subcommittee XIII on Shellac (J. W. Paisley, chairman).—This subcommittee withdrew its report and the recommended specifications originally appearing in this report as preprinted. The subcommittee considers the methods for the determination of matter insoluble in hot alcohol, Paragraphs 5 to 9, inclusive, of the Tentative Methods of Sampling and Testing Shellac (D 29 – 29 T) to be unsatisfactory and hopes that they may be replaced by a more satisfactory method or methods during the yesr.

Subcommittee XVIII on Physical Properties of Materials (F. P. Ingalls, chairman).—Because of the formation of the new Inter-Society Color Council, in which Committee D-1 took an active part, this subcommittee temporarily has no active work under way due to the fact that the line of work formerly carried on falls directly within the sphere of activities of the new organization.

Subcommittee XXVI on Underground Pipe Protection (F. N. Speller, chairman).—This new subcommittee held its organization meeting on April 5, 1932, and outlined its first objective as the development of specifications for priming coatings to be applied to steel pipe at the mill for protection during storage and shipment. The work was tentatively divided into three classes covering (1) cutback primers, (2) general utility primers of a temporary nature and (3) ideal or permanent types of primers. After consideration of these first tentative suggestions it is thought that the work of the subcommittee will become much more clearly defined.

The election of officers for the ensuing term of two years resulted in the selection of Allen Rogers, chairman, C. S. Neal, vice-chairman, and M. Rea Paul, secretary.

This report has been submitted to letter ballot of the committee, which consists of 168 members; 66 members returned their ballots, of whom 44 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

P. H. CATHCART,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Ethylene Glycol Mono Butyl Ether, for Ethylene Glycol Mono Ethyl Ether, for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent Grade), for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent Grade), and Tentative Method of Test for Comparative Hiding Power of Paints were accepted for publication as tentative and appear on pages 738 to 746.

The proposed revisions of the Standard Specifications for Basic Carbonate White Lead; Standard Methods of Routine Analysis of White Pigments; of White Linseed Oil Paints; of Dry Red Lead; of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese; of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green; of Titanium Pigments; of Dry Cuprous Oxide; of Dry Mercuric Oxide, and Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments were accepted for publication as tentative and appear on pages 1003, 1007 to 1015.

The proposed revisions of the Tentative Specifications for Glazier's Putty and of the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels were accepted. The tentative standards in their revised form appear on pages 736 and 742, respectively.

REPORT OF SUBCOMMITTEE VII ON ACCELERATED TESTS FOR PROTECTIVE COATINGS

Subcommittee VII has held two meetings during the past year, one on June 24, 1931, and the other on April 4, 1932.

The subcommittee has carried through a cooperative test program for finally approving western red cedar as panel material in accelerated weathering test work, and based on the results obtained has prepared proposed Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes. The change from the original specifications has been the omission of any reference to panel size. A copy of the proposed specifications is appended to this report for information.

The subcommittee has also taken action to get under way a cooperative test program for evaluating weathering cycles now in use among the various laboratories.

The nomenclature for paint failures and the methods for recording results of inspections have been given consideration through the presentation of the following papers before the subcommittee at the meeting on June 24, 1931:

Dr. J. K. Hunt, "Definitions of the Types of Failure Which Occur on the Outdoor Exposure of Varnishes, Enamels, Lacquers and Paints."

W. R. Fuller and G. D. Patterson each discussed: "Graphical Methods for Presenting and Recording Paint Failures."

Respectfully submitted on behalf of the subcommittee,

H. A. Nelson,
Chairman.

APPENDIX

PROPOSED SPECIFICATIONS FOR WOOD TO BE USED AS PANELS IN ACCELERATED WEATHER TESTS OF PAINTS AND VARNISHES[1]

1. *Purpose and Scope.*—According to experience, the wood used as a test surface has a marked bearing upon the weathering results, especially in accelerated systems where wood failures such as slitting and cracking are greatly emphasized. It is the purpose of these specifications to obtain uniformity of the wood used for accelerated tests, particularly where cooperative work between laboratories is undertaken. Only the testing of finishes upon what may be considered an ideal wood surface is to be covered by these specifications. Test panels, covering woods difficult to keep coated, are to be prepared for the present according to the practices now being followed in the individual laboratories.

2. *Species to be Used.*—Western red cedar (*thuja plicata*).

3. *Weight per Cubic Foot.*—Twenty-two to twenty-three pounds per cubic foot, this weight to be taken after at least one week's storage in a protected, dry, warm place (approximately 70° F.)

4. *Texture of Wood.*—Material to be close grained, as nearly edge grain as possible and in no section to vary more than 45 deg. from edge grain.

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[1] Criticisms of these proposed specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., New York City.

REPORT OF SUBCOMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

The present calculation methods for the analysis of basic sulfate white lead in the Standard Methods of Routine Analysis of White Pigments (D 34 - 30) do not give accurate results with the pigments now on the market. The manufacturers of basic sulfate white lead requested Subcommittee VIII to delete the present methods and to substitute methods similar to those given in the Bureau of Standards *Circular No. 85* (replaced by Federal Specification TT-W-261). The latter methods apply to all types of basic sulfate white lead, are more accurate than the present methods, and have proven satisfactory in use in the Government laboratories during the past 10 years. The subcommittee at a meeting on June 15, 1931, voted unanimously to recommend this change and this action was subsequently reported to Committee D-1 at its meeting on June 23, 1931. Correspondence with certain laboratories indicates that some of the standard methods might be made more useful by making minor changes or additions. The subcommittee, therefore, recommends that the following revisions in 9 standard methods under the jurisdiction of the committee be accepted for publication as tentative revisions:

Standard Methods of Routine Analysis of White Pigments (D 34 - 30):[1]

Change section heading "General Method" to read "General Methods" and add the following new paragraph:

> Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Omit the entire section under Basic Sulfate of Lead and substitute the following methods:

BASIC SULFATE OF LEAD

Qualitative Analysis.—Test for matter insoluble in acid ammonium acetate solution, for calcium, for carbonates, and for any other impurities suspected, by the regular methods of qualitative analysis.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 367.

Moisture.—Place 1 g. of the sample in a tared, wide-mouth, short, weighing tube provided with a glass stopper. Heat with stopper removed for 2 hours at a temperature between 105 and 110° C. Insert stopper, cool and weigh. Calculate loss in weight as moisture.

Insoluble Impurity and Total Lead.—In a 250-cc. beaker, moisten 1 g. of the pigment with a few drops of alcohol; add 50 cc. of acid ammonium acetate solution (made by mixing 150 cc. of 80 per cent acetic acid, 100 cc. of water, and 95 cc. of ammonium hydroxide (sp. gr. 0.90)). Heat to boiling and boil for 2 minutes. Decant through a filter paper leaving any undecomposed matter in the beaker. To the residue in the beaker, add 50 cc. of the acid ammonium acetate solution, heat to boiling and boil for 2 minutes. Filter through the same paper and wash with hot water. If an appreciable residue remains, ignite and weigh as insoluble impurity. Unite the acid ammonium acetate solutions, heat to boiling, and add dropwise, while stirring, a slight excess (in total about 10 to 15 cc.) of a 10 per cent solution of potassium dichromate. Heat until the precipitate assumes an orange color, let settle, filter on a weighed Gooch crucible, wash by decantation with hot water until the washings are colorless, and finally transfer all of the precipitate to the crucible. Then wash with 10 cc. of 95 per cent ethyl alcohol and finally with 10 cc. of ethyl ether. Dry at 105 to 110° C., cool, and weigh $PbCrO_4$. Calculate to PbO by multiplying by the factor 0.69.

Zinc Oxide.—Weigh accurately about 1 g. of the pigment, transfer to a 400-cc. beaker, add 30 cc. of HCl (1:2), boil for 2 or 3 minutes, add 200 cc. of water and a small piece of litmus paper, add NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with standard potassium ferrocyanide as in standardizing that solution. Calculate total zinc as ZnO.

The standard potassium ferrocyanide solution is prepared and standardized as follows: Dissolve 22 g. of the pure salt in water and dilute to 1000 cc. and mix. To standardize, transfer about 0.2 g. (accurately weighed) of pure metallic zinc or freshly ignited pure ZnO to a 400-cc. beaker. Dissolve in 10 cc. of HCl and 20 cc. of water. Drop in a small piece of litmus paper, add NH_4OH until slightly alkaline, then add HCl until just acid and finally add 3 cc. of strong HCl. Dilute to about 250 cc. with hot water and heat nearly to boiling. Run in the ferrocyanide solution slowly from a burette with constant stirring until a drop tested on a white porcelain plate with a drop of the uranyl indicator (a 5 per cent solution of uranyl nitrate in water or a 5 per cent solution of uranyl acetate in water made slightly acid with acetic acid), shows a brown tinge after standing 1 minute. A blank should be run with the same amounts of reagents and water as in the standardization. The amount of ferrocyanide solution required for the blank should be subtracted from the amounts used in standardization and in titration of the sample. The standardization must be made under the same conditions of temperature, volume, and acidity as obtained when the sample is titrated.

Lead Sulfate.—Treat 0.5 g. of the pigment in a 400-cc. beaker with a few drops of alcohol, add 10 cc. of bromine water, 10 cc. of HCl (1:1) and 3 g. of NH_4Cl. Cover with a watch glass and heat on a steam bath for 5 minutes, add hot water to give a total volume of about 200 cc. boil for 5 minutes, filter to separate any insoluble matter (a pure pigment should be completely dissolved), and wash thoroughly with hot water. (The insoluble matter may be ignited, weighed, and examined qualitatively.) Neutralize the clear solution (original solution or filtrate from insoluble matter) in a covered beaker with dry Na_2CO_3, add 1 g. more of dry Na_2CO_3, and boil 10 to 15 minutes. Wash off cover, let settle, filter, and wash with hot water. Redissolve the precipitate in HCl (1:1), reprecipitate with Na_2CO_3 as above, filter, and wash thoroughly with hot water. Acidify the united filtrates with HCl, adding about 1 cc. in excess. Boil to expel bromine, and to the clear boiling solution add slowly while stirring 15 cc. of 10 per cent barium chloride solution. Let stand on steam bath for about 1 hour, filter on a weighed Gooch crucible, wash thoroughly with boiling water, dry, ignite, cool, and weigh as $BaSO_4$. Calculate to $PbSO_4$, using the factor 1.3.

Calculations.—Calculate the percentage of $PbSO_4$ to PbO by multiplying by the factor 0.736 and subtract the result from the percentage of PbO found under *Insoluble Impurity and Total Lead;* report the difference as PbO. Report ZnO found under *Zinc Oxide* as percentage of ZnO. Moisture and insoluble matter are reported as such.

Zinc-Lead and Leaded-Zincs.—Under first section headed *Total Lead and Zinc*, in next to last sentence after the words "potassium-ferrocyanide solution" add the phrase "as described under basic sulfate of lead."

Zinc Oxide.—Under section headed *Total Zinc*, at end of first sentence for the words "by Low" substitute "as described under basic sulfate of lead." In the last sentence add a footnote reference number two after "Low."

Lithopone.—Under section headed *Insoluble and Total Zinc*, in next to last sentence for the words "under zinc white" substitute "described under basic sulfate of lead."

Change section headed *Zinc Oxide* to read as follows:

Weigh accurately 1 g. of the lithopone, transfer to a 250-cc. beaker (moisten with a few drops of alcohol if an extracted pigment), add about 100 cc. of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$, as described under basic sulfate of lead. Calculate to ZnO. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.).

Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 29):[1]

Testing Non-Volatile Vehicle.—At the end of Section *A*, *Preparation of Fatty Acids*, add the following new paragraph:

> Instead of the preceding method the following procedure may be used, especially with samples that give trouble by the former: To about 50 g. of paint in a porcelain casserole, add 30 cc. of aqueous 30 per cent NaOH and 125 cc. of ethyl alcohol, mix and evaporate on steam bath until residue is dry. Transfer to a 400-cc. beaker and boil with 200 cc. of water, add H_2SO_4 (sp. gr. 1.2) (25 cc. in excess), boil, stir, filter through large coarse paper, and drain. Scrape mass into a flask, shake violently with ether, centrifuge, decant into a separatory funnel, and wash with small amounts of water until free of H_2SO_4. Transfer ether solution to dry flask and leave over about 40 g. of anhydrous sodium sulfate until ether layer is clear. Decant the clear solution through filter paper into a dry 100-cc. flask. Pass a rapid current of dry air into the mouth of the flask and heat to a temperature below 75° C. on a dry hot plate until the ether is entirely removed. The fatty acids prepared as above should be kept in a stoppered flask and examined at once.

Under Section (2), Mixed or Composite Pigments, in the paragraph on *Insoluble Matter*, add the following sentence between the fourth and fifth sentences from the end of the first paragraph:

> In order to make sure that practically no silica is occluded by the $BaSO_4$ as finally weighed, especially with pigments high in siliceous matter, the following step may be taken at this point: evaporate the HCl solution to dryness, and heat at about 150° C. for one-half to one hour; moisten the residue with concentrated HCl, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper, and wash thoroughly with hot water.

Also under (2) Mixed or Composite Pigments, in the second paragraph under "Total Lead (Antimony)," change the seventh sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> [Moisten the residue with a few drops of HCl,] *To the residue add sufficient concentrated HCl to dissolve the $PbSO_4$ (with pigments containing considerable amounts of $PbSO_4$, it may be necessary to add 15 to 20 cc. of concentrated HCl)*, add about 50 cc. of hot water, boil a few minutes, filter hot through paper, and wash with hot water until washings give no test for lead.

In the procedure for *Total Zinc* under B. Quantitative Analysis, (2) Mixed or Composite Pigments, change Paragraph (*d*) to read as follows:

> (*d*) With pigments containing ZnO and ZnS, the ZnO may be determined as follows: Weigh accurately 1 g. of the pigment, transfer to a 250-cc. beaker, moisten with alcohol, add about 100 cc. of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 378.

followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$ solution as above. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.)

In the last sentence of the fourth paragraph at the end of the methods change the footnote to the procedure of the Federal Specifications Board to read as follows:

Federal Specifications Board, Federal Specification TT-P-36 for Paints; Lead-Zinc Base, Ready-Mixed and Semipaste, White and Tinted, p. 2: "The total lead dissolved in dilute acetic acid and hot ammonium acetate, weighed as lead sulfate, and this weight multiplied by the factor 0.883 shall be considered white lead. It is not possible to determine the amount of lead carbonate and lead sulfate when carbonates or sulfates of other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds. The factor to convert $PbSO_4$ to $(PbCO_3)_2Pb(OH)_2$ is 0.854, to convert $PbSO_4$ to $PbSO_4PbO$ is 0.868, and to convert $PbSO_4$ to $(PbSO_4)_2PbO$ is 0.913. The arbitrary factor used under this specification is the mean of the largest and smallest of these factors."

Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 29):[1]

Add the following paragraph as a new Section 2, renumbering the present sections accordingly:

2. *Treatment of Sample.*—If the pigment is lumpy or not finely ground, it shall be ground to a fine powder and thoroughly mixed. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. All samples shall be preserved in stoppered bottles or containers.

Standard Methods of Routine Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese (D 50 - 27):[2]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 400.

[2] *Ibid.*, p. 406.

Section 14.—Change the first sentence of the third paragraph to read as follows by the addition of the italicized words:

> The NH_4OH precipitate is dissolved in hot dilute HCl, washing paper with hot water, cooled, oxidized with Na_2O_2, boiled *vigorously for 10 to 15 minutes* to expel H_2O_2, cooled, cover glass washed off, diluted to about 150 cc., and acidified with H_2SO_4.

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 27):[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

> 1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Section 7.—Change the ninth sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> [Render an aliquot portion acid with H_2SO_4, boil to expel any free oxygen, cool,] *Boil an aliquot portion vigorously for 10 to 15 minutes to expel* H_2O_2*, cool, acidify with* H_2SO_4, add an excess of standard $(NH_4)_2Fe(SO_4)_2.6H_2O$ solution and titrate back with 0.1 *N* $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ as outside indicator.

Also in this section change the second from the last sentence in the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> If iron or aluminum are not to be determined or are present in negligible amounts, the first NH_4OH precipitate may be dissolved in dilute HCl, oxidized with Na_2O_2, [acidified with H_2SO_4, boiled,] *boiled vigorously for 10 to 15 minutes to expel* H_2O_2*, cooled, acidified with* H_2SO_4, and CrO_3 determined volumetrically.

Section 11.—In the third sentence change "20 cc." to read "25 cc."

Section 22.—Change from its present form: namely,

> 22. Make the test for water-soluble matter in accordance with Section 11.

to read as follows:

> 22. Transfer 2.5 g. of the pigment to a graduated 250-cc. flask, fill to the mark with water and stopper. Shake vigorously and let stand at room tem-

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 413.

perature for not less than 15 hours, shaking vigorously from time to time. Then let settle, filter through a dry filter paper and discard the first 25 cc. of the filtrate. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam bath, dry for one hour in an oven at 105 to 110° C., cool and weigh. Calculate the percentage of water-soluble matter.

Section 38.—Change to read as follows by the addition of the italicized words:

38. On a separate sample determine the sulfate directly with Na_2CO_3 as in the preceding paragraph, without any preliminary treatment with bromine water *or nitric acid.*

Section 53.—Change the reference from "Section 11" to read "Section 22."

New Methods.—Add the following Methods of Analysis of Chrome Oxide Green as Sections 55 to 57:

METHODS OF ANALYSIS OF CHROME OXIDE GREEN

Chrome oxide green is practically pure sesquioxide of chromium (Cr_2O_3) without any admixture.

Moisture

55. Determine moisture in accordance with Section 45.

Water-Soluble Matter

56. Determine water-soluble matter in accordance with Section 11.

Total Chromium

57. Mix thoroughly about 0.25 g. (accurately weighed) of the sample with approximately 5 g. of sodium peroxide (containing at least 90 per cent Na_2O_2) in a 30-cc. pure iron crucible (ordinary iron crucibles may contain some chromium and manganese) and fuse carefully over a gas flame. Five minutes fusion at a low red heat after the mass has melted will insure complete decomposition. Allow the crucible to partly cool, and while tightly covered, tap on an iron plate to loosen the fusion in a solid cake. Place the cake in a covered beaker and dissolve with 200 cc. of warm water. Rinse the crucible and cover with warm water, adding to the main portion. Add approximately 1 g. of sodium peroxide and boil the solution for 10 minutes. Cool and acidify with sulfuric acid (50 cc., 1:1 sulfuric acid). A clear solution with a few scales of magnetic oxide should result. Immediately cool again, add 5 cc. of phosphoric acid (sirup, sp.gr. 1.725), transfer to an 800-cc. beaker and dilute with cold water to 500 cc. Add an accurately measured excess (about 100 cc.) of approximately 0.1 N ferrous ammonium sulfate to the solution while stirring. When reduction is complete a deep pure green color should develop, and a drop of the liquid when tested with a drop of dilute potassium ferricyanide solution should give a blue color. Set the beaker about ½ in. above a white tile to secure good light. Determine the excess of ferrous sulfate by titration with a standard solution (approximately 0.1 N) of potassium permanganate. Take the first faint permanent darkening of the clear green color as the end point. Addition of more permanganate increases the depth of the color which finally becomes purple. The end point is quite sharp and well defined, but requires some practice. If the ferrous salt has been standardized against dichromate, subtract the required number of cubic centimeters of 0.1 N per-

manganate from the number of cubic centimeters of 0.1 *N* ferrous solution. The difference represents the number of cubic centimeters of 0.1 *N* ferrous solution which multiplied by 0.001733 g. gives the grams of chromium present. Where the ferrous solution has been standardized against sodium oxalate, it is necessary to substract a "blank" from the permanganate titration. This "blank" is obtained as follows: When the end point is reached and the readings have been noted, add about 5 cc. excess of the ferrous solution and oxidize the excess of ferrous iron by adding 8 cc. of a 15 per cent solution of ammonium persulfate. Stir the liquid vigorously for one minute. Carefully add 0.1 *N* permanganate to the solution with constant stirring until the same end point is obtained as before. The volume of permanganate required, usually 0.2 to 0.4 cc., constitutes the "blank" to be deducted from the volume of the permanganate titration.

NOTE.—*Example:* In the determination of chromium in a 0.5000-g. sample 190.0 cc. of a 0.11 *N* ferrous solution and 11.00 cc. of a 0.1 *N* permanganate (11.40 – 0.4 cc. blank) were employed. The calculations are as follows:

$$190.0 \times 1.100 = 209.0 \text{ cc. of } 0.1\ N \text{ ferrous solution;}$$
$$209.0 - 11.00 = 198.00 \text{ cc.}$$
$$198.0 \times 0.001733 \times 2 \times 100 = 68.62 \text{ per cent Cr.}$$

Standard Methods of Routine Analysis of Titanium Pigments (D 186 – 29):[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Standard Method of Routine Analysis of Dry Cuprous Oxide (D 283 – 29);[2] *and Standard Method of Routine Analysis of Dry Mercuric Oxide (D 284 – 29):*[3]

In these two methods add the following paragraph as a new Section 1, renumbering the present Sections 1 and 2 as Sections 2 and 3:

1. Treatment of Sample.—If the pigment is lumpy or not finely ground, it shall be ground to a fine powder and thoroughly mixed. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample shall in all cases be thoroughly mixed before taking portions for analysis. All samples shall be preserved in stoppered bottles or containers.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 426.

[2] *Ibid.*, p. 432.

[3] *Ibid.*, p. 434.

Standard Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 31):[1]

Section 4.—Change the seventh sentence from its present form: namely;

> Admit air slowly to the desiccator by means of the pinch-cock or stop-cock, remove the cover, replace the stopper in the weighing bottle and weigh.

to read as follows:

> Admit air, that has been dried by passage through *fresh* magnesium perchlorate trihydrate, slowly to the desiccator by means of the pinch-cock or stop-cock, remove the cover, quickly replace the stopper in the weighing bottle and weigh.

Explanatory Notes.—After the word "pump" in Section 3 (*b*) insert "(Note 1)." Place the present note at the end of the methods numbering it as Note 1 under a central heading Explanatory Notes.

At the end of Section 3 (*d*) insert "(Note 2)" and place the present note at the end of the methods as Note 2.

After the word "constant" in Section 4 insert "(Note 3)." Transpose the present note to the end of the methods as Note 3.

At the end of Section 4 insert "(Note 4)." Add the following Note 4 to the Explanatory Notes:

> Note 4.—This is an arbitrary method and the details should be strictly followed. The determination of the true hygroscopic moisture content of very finely divided pigments is very difficult, if not impossible in some cases.

The subcommittee recommends that the Tentative Method of Test for Tinting Strength of White Pigments (D 332 – 31 T) be continued as tentative without revision.

A cooperative study on the determination of the hiding power of wet paints was carried out during the past year. A summary prepared from the reports of the cooperators is appended. As a result of these studies, the subcommittee submits herewith a Proposed Tentative Method of Test for the Comparative Hiding Power of Paints, appended hereto,[2] and recommends it for publication as tentative.

Respectfully submitted on behalf of the subcommittee,

F. W. SMITHER,
Chairman.

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 88.

[2] See p. 745.—ED.

APPENDIX

REPORT OF COOPERATIVE WORK ON THE DETERMINATION OF HIDING POWER OF WET PAINTS

At the meeting of Subcommittee VIII on Methods of Analysis of Paint Materials held in Indianapolis, Ind., on April 1, 1931, a program was outlined which was designed to establish the relation between the Pfund cryptometer and the Gardner brush-out board as instruments for measuring the hiding power of wet paints. It was further agreed that this work would be done on a predetermined schedule in order that the paints would be essentially the same when tested in each laboratory.

TABLE I.—LIST OF COOPERATORS.

Cooperator	Name	Organization	Date Received
No. 1	H. A. Gardner	Gregg Memorial Inst.	May 7
No. 2	C. R. Bragdon	Ault & Wiborg Varnish Works	May 7
No. 3	B. R. Silver	The New Jersey Zinc Sales Co	May 7
No. 4	E. F. Hickson	U. S. Bureau of Standards	May 7
No. 5	R. W. McKinney	Commercial Pigments Corp	May 8
No. 6	P. H. Cathcart	National Lead Co	May 8
No. 7	F. H. Kenney	New York City Testing Laboratory	May 9
No. 8	G. S. Haslam	Fundamental Research Division, The New Jersey Zinc Co	May 9
No. 9	R. H. Sawyer	Grasselli Chemical Co	May 11
No. 10	F. H. Long	Sherwin-Williams Co	May 14
No. 11	F. W. Hopkins	Murphy Varnish Co	May 15
No. 12	E. W. Boughton	R. T. Vanderbilt Co	May 16
No. 13	S. Werthan	Pigment Research Division, The New Jersey Zinc Co	May 20
No. 14	G. D. Patterson	E. I. du Pont de Nemours and Co	May 20
No. 15	W. R. Fuller	Pratt & Lambert, Inc	May 21
No. 16	F. P. Ingalls	John W. Masury and Son	May 26

The time schedule was rigorously adhered to and the cooperation evidenced in getting 16 laboratories to submit reports within three weeks of the receipt of the samples is significant of the interest which centers in the subject of hiding power measurement. Table I shows the list of the cooperators from whom reports were received and in Table IV are listed the analyses of the paints which were submitted with no other identification than a letter and the weight per gallon.

TABLE II.—RESULTS OBTAINED ON GARDNER BRUSH-OUT TEST, SQ. FT. PER GAL.

	PAINT MARKED							
COOPERATOR	A	B	C	D	E	F	G	H
No. 1	399	162	192	154	268	152	192	105
No. 2	331	169	192	154	264	135	197	114
No. 3	393	180	209	164	265	146	226	130
No. 4	451	219	263	198	343	180	269	149
No. 5	308	154	203	152	227	135	193	113
No. 6	352	181	198	161	287	147	218	129
No. 7	338	147	177	141	252	121	201	109
No. 8	382	174	203	154	312	147	178	125
No. 9	399	177	211	165	292	145	210	124
No. 10	385	179	231	170	306	160	211	128
No. 11	487	291	238	218	325	173	103	121
No. 12	334	176	206	159	290	156	234	123
No. 13	333	169	217	164	287	152	202	122
No. 14	400	172	210	158	292	136	151	123
No. 15	353	184	236	171	274	...	218	131
No. 16[a]	399	201	221	198	270	136	223	123
Mean	376	182	212	166	286	149	200	123
Average Deviation from the Mean, per cent	10	10	8	8	7	8	13	6
Average of Average Deviations, per cent								8.8

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[a] Results from cooperator No. 16 not included in averages.

TABLE III.—RESULTS OBTAINED ON PFUND CRYPTOMETER, SQ. FT. PER GAL.

	PAINT MARKED							
COOPERATOR	A	B	C	D	E	F	G	H
No. 1	389	211	249	191	357	184	230	148
No. 2	581	291	323	298	448	242	342	215
No. 3	430	188	242	200	321	166	232	139
No. 4	495	243	305	237	376	202	312	182
No. 5	464	238	295	235	376	206	307	173
No. 6	613	323	416	291	448	277	378	233
No. 7	...	...	...	...	...	...	...	...
No. 8	377	187	228	181	327	150	194	135
No. 9	328	164	233	171	296	140	193	136
No. 10	493	213	279	214	362	165	265	172
No. 11	...	...	...	...	...	...	...	...
No. 12	485	224	290	215	342	188	232	194
No. 13	372	193	233	202	324	159	230	153
No. 14	574	243	315	266	447	197	281	188
No. 15	360	234	319	237	415	164	243	147
No. 16	...	...	...	...	...	...	...	...
Mean	459	229	287	226	372	188	265	170
Average Deviation from the Mean, per cent	17	14	13	14	11	15	17	15
Average of Average Deviations, per cent								14.5

In Table II are tabulated the results obtained by the Gardner brush-out test. In cases where laboratories submitted results of more than one operator these results were averaged. At the foot of the table is shown the mean as well as the average deviation from the mean. The report from cooperator No. 16 was not received until after these averages were calculated, and since the variation of the results from this laboratory was not sufficient to materially change any of the averages, the averages were not recalculated.

TABLE IV.—PAINTS SUBMITTED FOR TEST.

PAINT MARKED	WEIGHT OF PAINT PER GALLON, LB.	PIGMENT	PIGMENT, PER CENT	VEHICLE, PER CENT[a]
A	12.1	Titanium oxide	50	50
B	13.9	Lithopone	58.7	41.3
C	16.0	Commercial paint (lead, zinc oxide, titanox)	65.8	34.2
D	18.4	Basic lead carbonate	68.4	31.6
E	12.8	Zinc sulfide	54.1	45.9
F	15.7	Commercial paint (lead, zinc oxide)	60.1	39.9
G	14.4	Barium-titanium pigment	60.8	39.2
H	12.2	Zinc oxide	46.3	53.7

[a] Except for paints C and F, the vehicle was a commercial mill gloss vehicle containing 28 per cent volatile thinner.

Table III shows the actual results obtained on the Pfund cryptometer and again the mean and the average deviation from the mean are shown at the foot of the table. Cooperators Nos. 7, 11 and 16 did not submit cryptometer results.

From the values given in Tables II and III it will be noted that the cryptometer averages are 29 per cent higher than those obtained by the brush-out test.

REPORT OF SUBCOMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

During the past year, Subcommittee XV has given consideration to the various specifications under its jurisdiction and makes the following recommendations:

Standard Specifications for Basic Carbonate White Lead (*D 81 – 31*).[1]—The subcommittee has further considered these specifications and finds that the wording of the first sentence of Section 2 (*a*) unnecessarily restricts the process of manufacture, provided the other requirements of the specifications are met, by requiring the pigment to be the product made from metallic lead. Portions of the second sentence are also considered superfluous. The subcommittee accordingly presents the following revisions in these specifications and recommends that they be accepted for publication as tentative:

Section 2. (*a*) *Dry Pigment.*—Change this section to read as follows by the omission of the words in brackets and the addition of the italicized word:

> 2. (*a*) Dry Pigment.—The pigment [shall be the product made from metallic lead and] shall have a composition [corresponding approximately to] ***approximating*** the formula $2PbCO_3.Pb(OH)_2$. It [shall be thoroughly washed after corroding], shall be free from impurities [and adulterants], and shall meet the requirements given in Section 3.

Tentative Specifications for Glazier's Putty (*D 317 – 30 T*).[2]—Further study has been given to these specifications. Tests of commercial putties indicate that such great variety in the composition of the vehicle as permitted in these specifications is not necessary for pure putty. Some of the variations which are used in cheap commercial putties are the result of the adulteration of the vehicle. It is found undesirable to limit the vehicle to raw linseed oil; it is sometimes advisable to use a small percentage of bodied oil. If the solids of the putty are of the proper quality and finely ground, the percentage of oil will be quite closely set by the requirements for physical properties of the finished putty. A minimum limit on linseed oil does, however, help to exclude undesirable, coarsely ground limestone. It has also been found that the use of a No. 325 sieve in determining coarse particles and skins is unnecessarily severe.

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 76.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1065 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 345.

The subcommittee accordingly recommends that the specifications for putty be revised as follows and continued as tentative:

Title.—Change the title of the specifications to read as follows by the addition of the italicized words and the omission of the word in brackets:

Pure Linseed Oil [Glazier's] Putty *for Glazing.*

Omit the word "raw" before "linseed oil" wherever it occurs throughout the specifications.

Section 5 (a).—In the table of requirements for finished putty, increase the maximum limit for pigment from "87 per cent" to "88 per cent" in both classes of putty and omit the minimum value of 82 per cent. Also change the minimum requirement for linseed oil, in both classes of putty, from "13 per cent" to "12 per cent" and omit the maximum value of "18 per cent."

In the last item in the table covering coarse particles and skins, change "No. 325 sieve" to read "No. 200 sieve."

Respectfully submitted on behalf of the subcommittee,

H. E. SMITH,
Chairman.

REPORT OF SUBCOMMITTEE XXV ON CELLULOSE ESTER COATINGS

Subcommittee XXV held one meeting during the past year on April 4 at the U. S. Bureau of Standards, Washington, D. C., with 14 members and 4 visitors present.

The subcommittee has been very active during the past several years in preparing standards of quality for the various ingredients entering into the manufacture of cellulose ester coatings for use as protective coatings. These are intended to replace the various manufacturers' and users' specifications which now flood the market. They are also designed for the benefit of the smaller consumers having inadequate technical staffs in that they supply specifications which they can use and feel reasonably confident of the quality of any goods delivered under such specifications. The subcommittee recommends at this time for publication as tentative, as appended hereto, the following four specifications:

Tentative Specifications for Ethylene Glycol Mono Butyl Ether;[1]
Tentative Specifications for Ethylene Glycol Mono Ethyl Ether.[2]
Tentative Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (90 to 91 per cent Grade);[3]
Tentative Specifications for Acetate Ester of Ethylene Glycol Mono Ethyl Ether (95 to 96 per cent Grade);[4]

The subcommittee recommends that the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 31 T)[5] be revised as follows and continued as tentative:

Section 1 (*a*).—Change the figure "8.33" at the end of the first sentence to read "8.32."

New Method.—Add the following test procedure for non-volatile matter as a new section at the end of these methods:

9. *Non-Volatile Matter.*—Weigh into an aluminum dish containing a stirring rod, from 4 to 6 g. of the sample to be tested. Pour in 100 ml. of acetone and stir until solution of material is complete. Add slowly 10 ml. of water, stirring vigorously. Place the dish on a hot-water bath and allow the solution to evaporate to dryness. Heat for 1 hour in an oven at 100 to 105° C. Allow to cool 20 minutes in a desiccator and weigh. (The dish should be covered in such a manner as to allow solvents to escape and exclude contamination by dirt in the atmosphere.) If the precipitate or residue is lumpy, redissolve in the solvent combination and precipitate again with water.

The method of determining non-volatile matter in varnishes, as described in Sections 6 and 7 of the Standard Methods of Testing Oleo-Resinous Var-

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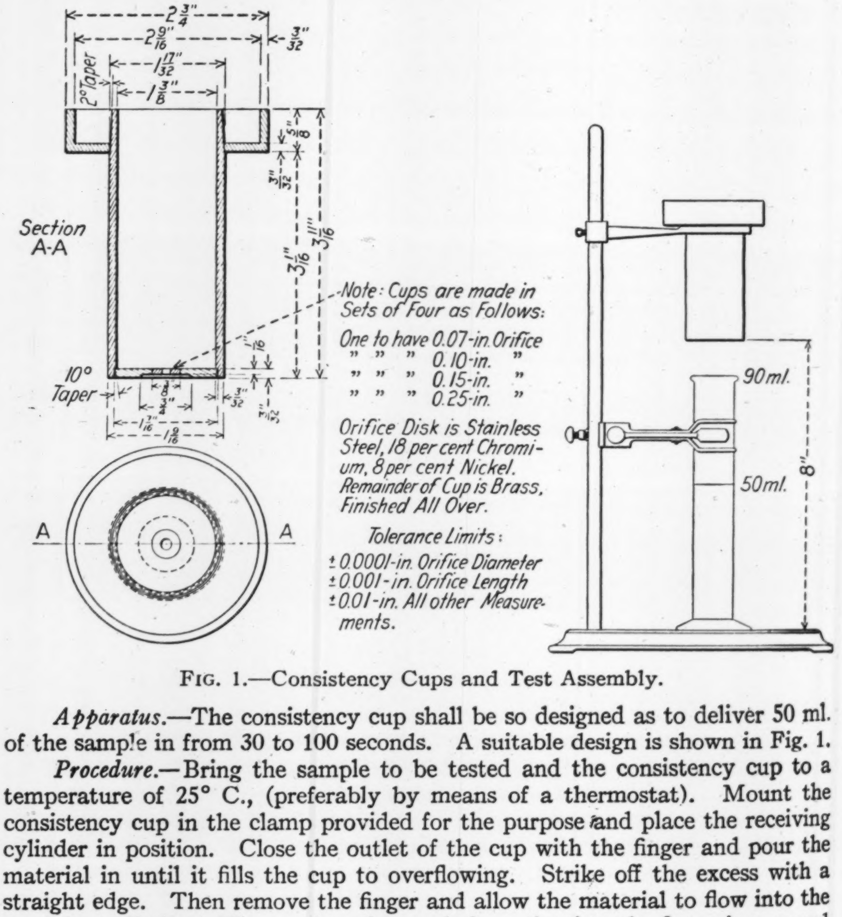
[1] See p. 738.—Ed. [2] See p. 739.—Ed. [3] See p. 740.—Ed. [4] See p. 741.—Ed.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 806 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 394.

nishes (A.S.T.M. Designation: D 154) of the American Society for Testing Materials, may be used if mutually agreed upon by buyer and seller.

Consistency Test.—The subcommittee has considered at considerable length the proposed method and apparatus for the determination of the consistency of nitrocellulose clear lacquers and lacquer enamels. The following proposed method is presented at this time as information:



Note: Cups are made in Sets of Four as Follows:

One to have 0.07-in. Orifice
" " " 0.10-in. "
" " " 0.15-in. "
" " " 0.25-in. "

Orifice Disk is Stainless Steel, 18 per cent Chromium, 8 per cent Nickel. Remainder of Cup is Brass, Finished All Over.

Tolerance Limits:

±0.0001-in. Orifice Diameter
±0.001-in. Orifice Length
±0.01-in. All other Measurements.

FIG. 1.—Consistency Cups and Test Assembly.

Apparatus.—The consistency cup shall be so designed as to deliver 50 ml. of the sample in from 30 to 100 seconds. A suitable design is shown in Fig. 1.

Procedure.—Bring the sample to be tested and the consistency cup to a temperature of 25° C., (preferably by means of a thermostat). Mount the consistency cup in the clamp provided for the purpose and place the receiving cylinder in position. Close the outlet of the cup with the finger and pour the material in until it fills the cup to overflowing. Strike off the excess with a straight edge. Then remove the finger and allow the material to flow into the receiving cylinder. The number of seconds from the time the finger is removed from the orifice until the top of the meniscus reaches the 50-ml. mark on the cylinder is determined by a stop-watch and is recorded as the consistency of the material.

Respectfully submitted on behalf of the subcommittee,

I. C. MATTHEWS,
Chairman.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants held three regular meetings during the past year (in June at Chicago, Ill., in January at Washington, D. C., and in March at Cleveland, Ohio), and also informal meetings in November at Chicago, Ill., and in June at Tulsa, Okla., at the time of meetings of the American Petroleum Institute.

At a special election held at the March meeting, Mr. T. A. Boyd, General Motors Corp., was elected chairman of the committee to fill the vacancy caused by the death of the former chairman, Mr. F. A. Hull.

During the year, a new Subcommittee I on Corrosion Test for Lubricating Oils was authorized and appointed with H. C. Mougey as chairman, also a special Subcommittee on Viscosity-Temperature Chart with T. G. Delbridge as chairman. The scope of Subcommittee XXVII on Transmission Lubricants Classification has been enlarged and the title changed to Classification of Transmission Lubricants and Automotive Greases.

At the March meeting, Technical Committee D on Stoddard Solvent was authorized and appointed to be identical in personnel with the present Standing Committee on Stoddard Solvent of the Division of Trade Standards of the U. S. Bureau of Standards. The officers of this new technical committee are:

Chairman: Lloyd W. Jackson, Mellon Institute
Vice-Chairman: W. J. Stoddard, National Association Institute of Dyeing and Cleaning
Secretary: Harry H. Steidle, Division of Trade Standards, U. S. Bureau of Standards.

Acting as Sectional Committee Z-11 on Methods of Testing Petroleum Products and Lubricants, functioning under the procedure of the American Standards Association, a recommendation to include nomenclature in the scope of the committee's activity was made. The object of the proposed change is to bring the scope of the committee's activity into conformity with the scope of the newly organized International Standards Association Technical Committee No. 28 on Nomenclature and Methods of Test of Petroleum Products, of which the American Standards Association has been assigned the secretariat.

The voting membership of Committee D-2 now consists of 39 producer, 32 consumer, and 9 general interest members.

ACTIVITIES OF SUBCOMMITTEES AND TECHNICAL COMMITTEES

Appended hereto are reports of Subcommittee XVI on Cloud and Pour Test, Technical Committee A on Gasoline and Technical Committee C on Fuel Oils (Including Diesel Fuel).

The special Subcommittee on Viscosity-Temperature Chart has developed a chart for ascertaining the viscosity of a petroleum oil at any temperature within a range of from −30 to 450° F., provided viscosities at two temperatures are known. The Viscosity-Temperature Chart was presented to the Society for publication as tentative through Committee E-10 on Standards. On March 8, 1932, Committee E-10 accepted the chart for publication as a tentative standard[1] under the title Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 – 32 T). Copies of the chart, 21½ by 16¼ in. in size, are obtainable separately or in pads of 25 each from the office of the Society.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

I. *Proposed Tentative Revisions of Standard Methods:*

The committee recommends for publication as tentative the following changes in three standard methods and editorial changes in two methods, as indicated:

Standard Method of Test for Cloud and Pour Points (D 97 – 30).[2]—The following minor change is recommended by Subcommittee XVI on Cloud and Pour Test (J. B. Rather, chairman) to eliminate errors due to indiscriminate interchangeable use of the "regular" and "low" pour-test thermometers:

Section 11.—Change the third sentence of the third paragraph to read as follows by the addition of the italicized word and numbers and the omission of those in brackets:

> Oils on which a [very low] pour point *below −30° F.* is expected shall be heated as above with the high cloud- and pour-test thermometer in position, cooled to 60° F. and the low cloud- and pour-test thermometer placed in position, and the assembly placed in the jacket.

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[1] In submitting this tentative standard to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: 63 members returned their ballots, of whom 53 voted affirmatively, 1 negatively and 9 refrained from voting.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 481.

Add the following sentence at the end of the third paragraph as an editorial change, thus permitting the determination of pour points above 115° F.:

Oils on which a pour point of above 90° F. is expected shall be heated to 115° F. or to a temperature 15° F. above the expected pour point, with the high cloud- and pour-test thermometer in position, and the test jar immediately introduced into the jacket.

Standard Method of Test for Flash and Fire Points by Means of Open Cup (D 92 - 24).[1]—The following changes are recommended by Subcommittee XII on Flash Point (J. B. Terry, chairman) involving a more detailed specification of the cup and a slight change in procedure covering asphalt and other solid bituminous material:

Section 2.—Add the following paragraphs and table as a new Section 2 and Paragraph (*a*) and reletter the present Section 2 as Paragraph (*b*):

2. The Cleveland open cup, a diagram of which appears in Fig. 1, shall include the following major parts:

(*a*) *Flash Cup.*—The cup shall be made of brass and shall conform to the following requirements:

	INCHES			CENTIMETERS		
	MINIMUM	NORMAL	MAXIMUM	MINIMUM	NORMAL	MAXIMUM
Inside diameter immediately below filling mark	$2\frac{15}{32}$	$2\frac{1}{2}$	$2\frac{17}{32}$	6.27	6.35	6.43
Outside diameter below flange	$2\frac{21}{32}$	$2\frac{11}{16}$	$2\frac{23}{32}$	6.75	6.83	6.91
Inside height from center of bottom to rim	$1\frac{9}{32}$	$1\frac{5}{16}$	$1\frac{11}{32}$	3.25	3.33	3.41
Thickness of bottom	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	0.28	0.32	0.36
Distance from rim to filling mark	$\frac{23}{64}$	$\frac{3}{8}$	$\frac{25}{64}$	0.91	0.95	0.99
Distance lower surface flange to bottom of cup	$1\frac{7}{32}$	$1\frac{1}{4}$	$1\frac{9}{32}$	3.10	3.18	3.26
Vertical distance upper surface flange to rim	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	0.28	0.32	0.36
Thickness of rim	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	0.20	0.24	0.28
Width of lower surface of flange	$\frac{9}{16}$	$\frac{19}{32}$	$\frac{5}{8}$	1.43	1.51	1.59

The bevelled edge of the cup shall be at an angle of approximately 45 deg. There may be a fillet of approximately $\frac{5}{32}$ in. (0.397 cm.) radius inside the bottom of the cup.

Figure 1.—Substitute the accompanying Fig. 1 for Fig. 1 in the present method.

Section 4 (b).—Change to read as follows by the addition of the italicized words and figures:

(*b*) The cup shall be filled with the oil to be tested in such a manner that the top of the meniscus is exactly at the filling line at room temperature. *When asphalt or other solid bituminous material is to be tested, it shall first be heated to a temperature not less than 300° F. nor more than 350° F., to render it sufficiently fluid. The cup shall then be filled with the hot fluid at this temperature in the same*

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 517.

manner as with oil. The subsequent procedure shall then be the same for both asphalt and solid bituminous material as with oil. The surface of the oil shall be free from bubbles. There shall be no oil above the filling line or on the outside of the apparatus.

Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30).[1] The following changes are recommended by Subcommittee V on Viscosity and have been indorsed by Subcommittee B-7 on Viscosity and Float Test of Committee D-4 on Road and Paving Materials:

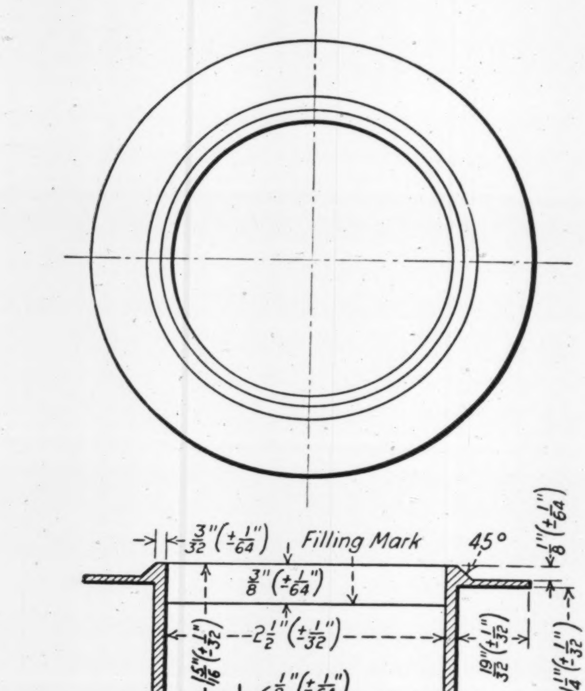

FIG. 1.—Cleveland Open Cup.

Section 3 (b).—Change the 212° F. test temperature with the Saybolt Furol Viscosimeter to 210° F., thus making this paragraph read as follows by the addition of the figures in italics and the omission of those in brackets:

(*b*) With the Saybolt Furol Viscosimeter, determinations shall be made at 77, 122 or [212] *210*° F. (25, 50 or [100] *98.9*° C.).

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 550.

Standard Method of Test for Thermal Value of Fuel Oil (*D 240 - 27*).[1]—The following editorial change is recommended for clarification:

Section 17.—Change from its present form: namely,

17. The permissible differences in duplicate determinations are as follows:

Same analyst	0.3 per cent
Different analysts	0.5 per cent

to read as follows:

17. The permissible difference between duplicate determinations made by different analysts on different calorimeters shall not exceed 0.5 per cent. When made by the same analyst on the same calorimeter, the permissible difference shall not exceed 0.3 per cent.

II. *Proposed Revisions of Tentative Standards:*

The committee proposes revisions of the following tentative methods of test and recommends that the methods as revised be continued as tentative:

Tentative Method of Test for Color of Lubricating Oils by Means of Union Colorimeter (*D 155 - 23 T*),[2] *and Tentative Method of Test for Color of Petrolatum by Means of Union Colorimeter* (*D 218 - 25 T*).[3]—The completely revised methods as recommended by Subcommittee VI on Color (H. M. Hancock, chairman) are appended hereto.[4] Among the changes incorporated in the proposed revised methods are: (*a*) addition of name plate in Section 2 (*a*); (*b*) deletion of provision for use of separate color glasses; (*c*) elimination of color standards A, D, and E; and (*d*) change in designation of daylight lamp.

Tentative Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (*D 287 - 30 T*).[5]—The following change is recommended by Subcommittee II on Specific Gravity (H. T. Bennett, chairman):

Section 9.—Add the following sentence to the second paragraph:

When extreme accuracy is desired instruments certified by the U. S. Bureau of Standards shall be used, and the necessary corrections made.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 545.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 677 (1923); also 1931 Book of A.S.T.M. Tentative Standards, p. 396.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 713 (1925); also 1931 Book of A.S.T.M. Tentative Standards, p. 401.

[4] See pp. 747 and 752, respectively.—Ed.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1122 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 419.

Tentative Method of Test for Vapor Pressure of Natural Gasoline (*Reid Method*) (*D 323 - 31 T*).[1]—The following changes are recommended by Subcommittee XXII on Natural Gasoline (G. G. Oberfell, chairman) to clarify the description of the apparatus and to provide corrections for widely varying barometric pressures:

Table II.—Substitute the accompanying Table I for Table II of the present method:

TABLE I.—CORRECTIONS TO CONVERT UNCORRECTED VAPOR PRESSURES TO REID VAPOR PRESSURES.

INITIAL AIR TEMPERATURE,[a] DEG. FAHR.	CORRECTIONS IN POUNDS PER SQUARE INCH FOR VARIOUS TEMPERATURES AS CALCULATED FOR NORMAL BAROMETRIC PRESSURES OF:				
	760 MM.	745 MM.	700 MM.	650 MM.	600 MM.
32	−2.9	−2.9	−2.7	−2.6	−2.5
40	−2.6	−2.6	−2.4	−2.3	−2.2
50	−2.2	−2.2	−2.1	−2.0	−1.9
60	−1.8	−1.8	−1.7	−1.6	−1.6
70	−1.4	−1.4	−1.3	−1.3	−1.2
80	−1.0	−1.0	−1.0	−0.9	−0.9
90	−0.5	−0.5	−0.5	−0.5	−0.5
100	0	0	0	0	0
110	+0.6	+0.6	+0.5	+0.5	+0.5

$$\text{Correction Factor} = \frac{(P_a - P_t)(t - 100)}{460 + t} - (P_{100} - P_t)$$

where t = the air chamber temperature at beginning of test, deg. Fahr.
P_t = the vapor pressure of water, lb. per sq. in., at t° F.
P_{100} = the vapor pressure of water, lb. per sq. in., at 100° F.
P_a = normal barometic pressure in lb. per sq. in. at place where test is conducted.

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[a] For intermediate air temperatures, the corrections should be interpolated to the nearest 0.1 lb. per sq. in.

Section 2 (*c*).—Change to read as follows by the addition of italicized words and numbers and the omission of those in brackets:

(*c*) Gasoline Chamber for Sampling Materials Under Pressure.—For testing natural gasoline where it is impracticable to obtain a sample by immersing the gasoline chamber in the liquid, as for example, gasoline in pressure storage or gasoline being transported by pipe line, [the gasoline chamber shall conform to the requirements specified in Paragraph (*b*) except that] a ¼-in. needle valve shall be attached near the bottom *of the gasoline chamber* and a ½-in. gate valve shall be introduced in the coupling between the chambers as illustrated in Fig. 1 (*b*). *The vertical dimensions of the gasoline chamber proper in Fig. 1* (*b*) *are such that the assembly fulfills the requirements of Paragraph* (*e*) *for the type of construction illustrated.*

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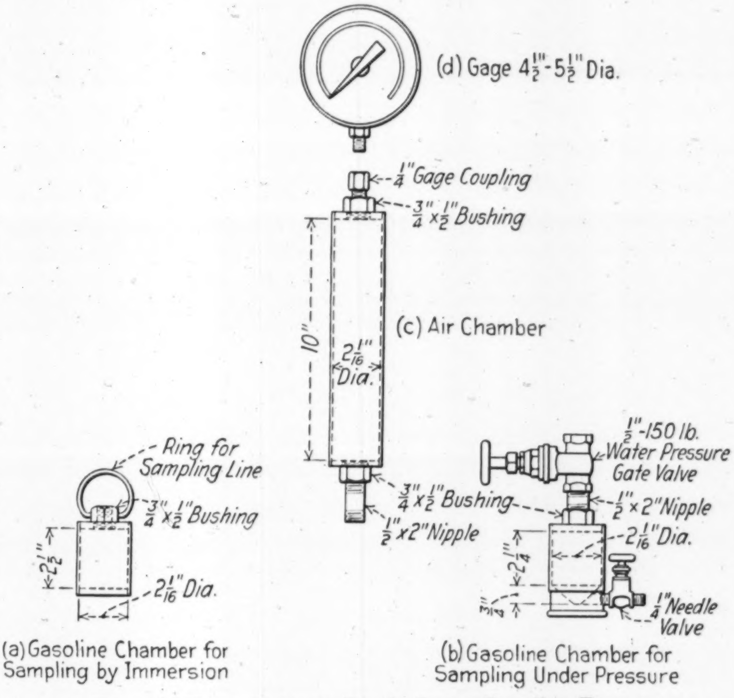
[1] *Proceedings*, Am. Soc. Testing Mats. Vol. 31, Part I, p. 808 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 471.

Section 2 (d).—Change the first sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

Any method of coupling the air and gasoline chambers may be employed, for example, a simple [screw] *thread, a* union, or a clamp.

Figure 1.—Substitute the accompanying Fig. 2 for Fig. 1 in the present method.


(d) Gage 4½"-5½" Dia.
¼" Gage Coupling
¾" x ½" Bushing
(c) Air Chamber
10"
2 1/16" Dia.
½"-150 lb. Water Pressure Gate Valve
Ring for Sampling Line
¾" x ½" Bushing
¾" x ½" Bushing
½" x 2" Nipple
½" x 2" Nipple
2 1/16" Dia.
2½"
2 1/16" Dia.
2¼"
¾"
¼" Needle Valve

(a) Gasoline Chamber for Sampling by Immersion

(b) Gasoline Chamber for Sampling Under Pressure

FIG. 2.—Vapor Pressure Bomb, Screw Coupling Type.

III. *Advancement of Tentative Revision of Standard Method to Standard:*

Standard Method of Test for Distillation of Natural Gas Gasoline (D 216 – 30).[1]—The committee recommends that the tentative revision proposed last year[2] be advanced to standard and incorporated in Standard Method of Test for Distillation of Natural Gas Gasoline (D 216 – 30). It is also recommended as an editorial change that the word "gas" be deleted in the expression "natural gas gasoline" in the title to this method and wherever it appears in the text.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 500.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1062 (1931); also 1931 Book of A.S.T.M Tentative Standards, p. 928.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARDS			
Test for Cloud and Pour Points (D 97 - 30)	51	1	4
Test for Flash and Fire Points by Means of Open Cup (D 92 - 24)	54	0	2
Test for Viscosity of Petroleum Products and Lubricants (D 88 - 30)	54	0	0
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Test for Color of Lubricating Oils by Means of Union Colorimeter (D 155 - 23 T)	49	1	6
Test for Color of Petrolatum by Means of Union Colorimeter (D 218 - 25 T)	47	1	8
Test for Gravity of Petroleum and Petroleum Products (D 287 - 30 T)	54	1	1
Test of Vapor Pressure of Natural Gasoline (Reid Method) (D 323 - 31 T)	47	0	9
III. ADVANCEMENT OF TENTATIVE REVISION OF STANDARD METHOD TO STANDARD			
Test for Distillation of Natural Gas Gasoline (D 216 - 30)	51	0	5

This report has been submitted to letter ballot of the committee which consists of 82 members; 56 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

T. A. BOYD,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Method of Test for Flash and Fire Points by Means of Open Cup and Test for Cloud and Pour Points were accepted for publication as tentative and appear on pages 1016 to 1018. Editorial changes in the latter method, proposed on the floor of the annual meeting, see Summary of Proceedings, page 19, were also approved.

Revisions of the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants, proposed on the floor of the annual meeting, see Summary of Proceedings, page 19, were accepted for publication as tentative and appear on page 1016.

The proposed revisions of the Tentative Methods of Test for Color of Lubricating Oils by Means of Union Colorimeter; for Color of Petrolatum by Means of Union Colorimeter; for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer; and for Vapor Pressure of Natural Gasoline (Reid Method) were accepted. The methods as revised appear on pages 747, 752, 757 and 765, respectively.

The advancement to standard of the tentative revision of the Standard Method of Test for Distillation of Natural Gas Gasoline was approved for reference to letter ballot of the Society for adoption. The method in its revised form appears in the 1932 Supplement to Book of A.S.T.M. Standards, page 41.

REPORT OF SUBCOMMITTEE XVI ON CLOUD AND POUR TEST

As a result of investigations conducted during the past year, it has been found that the "regular" and "low" pour-test thermometers are not strictly interchangeable. An error of from 5 to 8° F. may occur through indiscriminate interchangeable use of these thermometers for the determination of the pour point of oils when the pour point is below 0° F. It is therefore recommended that Section 11 of the Standard Method of Test for Cloud and Pour Points (D 97 – 30) be revised as shown in the report of Committee D-2.

In this same connection a study will be made of the value of a thermometer stem correction for the elimination of the small error which now exists in the determination of sub-zero pour points with the special low pour-test thermometer.

During the coming year consideration will be given to a new class of oils which have recently appeared on the market and which, it is reported, exhibit anomalous behavior when tested according to the standard method, in that the pour point shows some variation with the temperature of the cooling bath, even though the bath temperature be within the present specified limits.

A paper by R. W. Moore and L. C. Beard, Jr., entitled "A Microscopic Study of Certain Oils Which Show the Phenomenon of High and Low Pour Points" is included as an appendix to this report. This paper deals with work conducted in the chairman's laboratory during the past year and clarifies somewhat the theoretical aspects of high and low pour-point phenomena.

Respectfully submitted on behalf of the subcommittee,

J. B. Rather,
Chairman.

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APPENDIX

A MICROSCOPIC STUDY OF CERTAIN OILS WHICH SHOW THE PHENOMENON OF HIGH AND LOW POUR POINTS

By R. W. Moore[1] and L. C. Beard, Jr.[1]

In the 1931 report[2] of Subcommittee XVI on Cloud and Pour Test, results of pour point determinations on 15 samples of oil were given. Several of these oils exhibited anomalous behavior when tested according to the present Standard Method of Test for Cloud and Pour Points (D 97 – 30)[3] and had to be heated, prior to testing, to some temperature other than 115° F. in order to establish the highest pour point. By a microscopic examination of these oils under polarized light, we have arrived at a probable explanation for their anomalous behavior.

The oils investigated were those which showed particularly anomalous behaviour in the work described in the 1931 report of the subcommittee,[2] and were as follows:

Oils Tested	High Pour Point, A.S.T.M. Method D 97 – 30 deg. Fahr.	Highest Pour Point Obtainable, deg. Fahr.	Temperature to Which Oil Required to be Heated to Establish the Highest Pour Point, deg. Fahr
Cabin Creek cylinder stock, The Pure Oil Co....	65	90	100
Untreated steam-refined stock, Pierce Petroleum Corp....	65	90	135 – 150
Steam-refined stock, Mid-Continent Petroleum Corp....	70	80	120
Continental cylinder stock, Standard Oil Co. of New York....	105	105	115 – 220

Photomicrographs were made of these oils after they had been subjected to the various heat treatments as outlined in the Standard Method D 97 – 30[3] which show the characteristics of the oils under the actual pour test conditions. It was found that when the oil was heated to 220° F. and cooled, the anisotropic material separates in the form of large clusters of the character shown in Figs. 1(*b*), 2(*b*) and 3(*b*). On the other hand when heated to 115° F., or some other temperature found to give the highest pour point, very fine particles are obtained, as shown in Figs. 1(*a*), 2(*a*) and 3(*a*).

Apparently the phenomenon of low pour point is associated with large aggregates, and high pour point with small aggregates. In the case of the high pour point, the oil forms with the numerous fine particles an immobile fluid at a higher temperature than is the case when the larger clusters are formed. In the case of the low pour point, the large clusters are more segregated and the distribution more limited, which allows the oil to flow more freely and independently of the solid material present.

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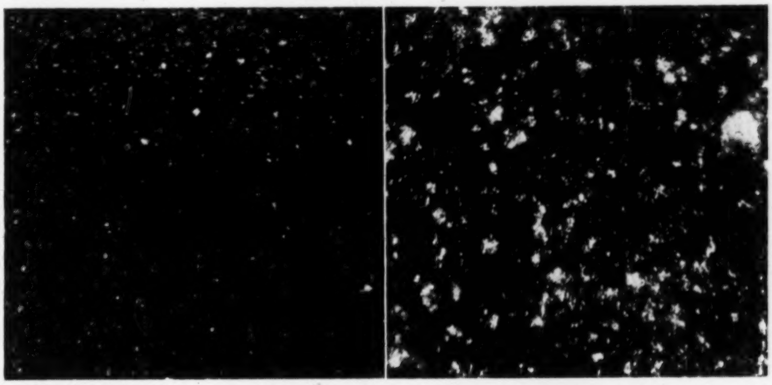
[1] Chemist, Standard Oil Co. of New York, Brooklyn, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 468 (1931).

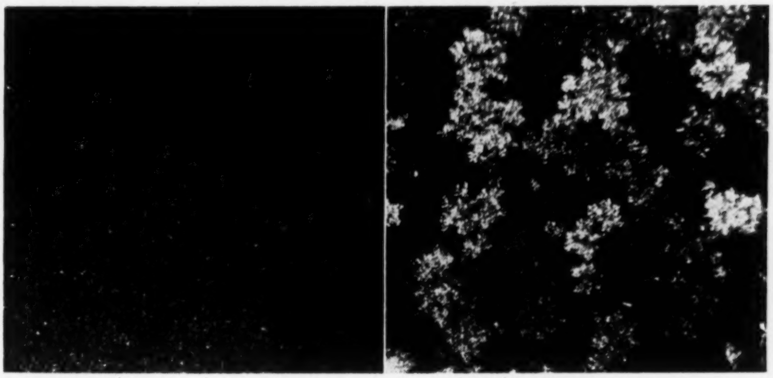
[3] 1930 Book of A.S.T.M. Standards, Part II, p. 481.

The anomalous results obtained for the high pour points of the oils tabulated above are believed to be caused by variations in the temperatures at which the anisotropic waxy material goes into solution in the oil. Oils for which this solution temperature is approximately 115° F. will give the highest possible pour point when Method D 97 – 30 is followed.



(*a*) Heated to 100° F. in a bath maintained at 103° F. (*b*) Heated to 220° F.

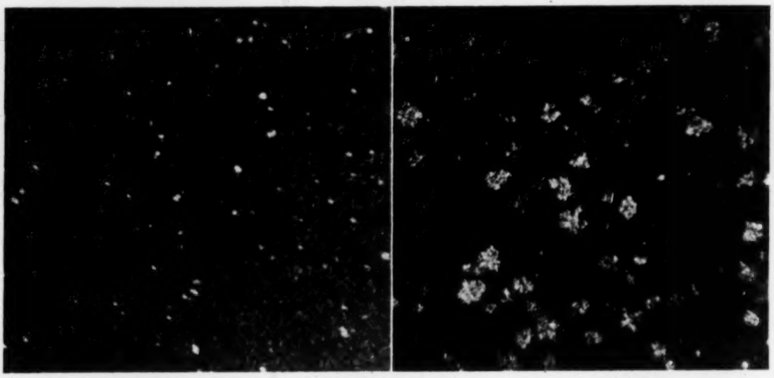
FIG. 1.—Cabin Creek Cylinder Stock from Pure Oil Co. (× 100).



(*a*) Heated to 140° F. in a bath maintained at 145° F. (*b*) Heated to 220° F.

FIG. 2.—Untreated Steam-Refined Stock from Pierce Petroleum Corp. (× 100).

In the case of the untreated steam-refined stock, the highest pour point was not obtained until the oil was preheated to approximately 135 to 150° F. When a drop of this oil was slowly heated on a microscope slide by means of a hot stage, it was found that the waxy material did not entirely disappear until a temperature of 130 to 140° F. had been reached. These two observations indicate that in order to establish the highest possible pour point it is necessary to heat the oil to such a temperature that the aggregates just melt, but not to such a high temperature that the conditions for the formation of large clusters and a low pour point are obtained. The conditions of the aggregates, when a high and a low pour point are obtained, are shown in Fig. 2(*a*) and (*b*), respectively.



(*a*) Heated to 120° F. in a bath maintained at 123° F.

(*b*) Heated to 220° F.

FIG. 3.—600 Steam-Refined Cylinder Stock from Mid-Continent Petroleum Corp. (× 100).

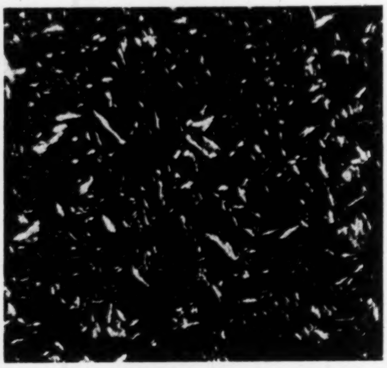


FIG. 4.—Continental Cylinder Oil from Standard Oil Co. of New York. Heated to 115 to 220° F. (× 100).

In the case of the Cabin Creek cylinder stock, an anomaly in the other direction exists. The temperature required to establish the high pour point is 100° F. and at this temperature it was also found that the solid material just went into solution. The characteristics of this oil under high and low pour point conditions are shown in Fig. 1(*a*) and (*b*), respectively.

The steam-refined stock behaves in a more normal manner. The anisotropic waxy material goes into solution at 115 to 120° F., and the preheating temperature for the establishment of the highest pour point is 120° F. Figure 3(*a*) and (*b*) shows the wax aggregates in this oil under high and low pour point conditions, respectively.

The Continental cylinder stock has high and low pour points which are identical. The large and small aggregates are lacking and the appearance of the anisotropic material more nearly resembles that of the crystalline waxes as observed in petrolatum and paraffin distillates. Furthermore, the wax in this sample shows a sharp and definite crystallization point when cooled slowly under the microscope. This condition is lacking in the case of the other three oils tested. The character of this oil is shown in Fig. 4.

From the above discussion it can be seen why some oils are more sensitive to storage conditions than others. When an oil which shows a difference in the high and low pour points is stored for a period of time at a temperature near the point where the aggregates will go into solution, it will have a tendency to acquire the condition of the high pour point.

The above work, it is believed, indicates that the phenomenon of high and low pour point is intimately related to the solution temperature of the waxy material in the oil and points to the improbability of developing a method which will be universally applicable to all oils.

REPORT OF TECHNICAL COMMITTEE A ON GASOLINE

Technical Committee A has been very active during the year through its several sections on gum, corrosion, vapor lock and detonation. The progress of the work of these groups is discussed below.

The Section on Gum (T. H. Rogers, chairman) has conducted service tests to correlate the maximum content of gum by the air-jet and the hot air-jet methods with behavior of fuels in service. The results of these tests and a description of the two methods for information are included in Appendix I to this report. Work on gum stability tests is also being undertaken.

The Section on Corrosion (J. B. Terry, chairman) is inactive pending the report of a joint ways-and-means committee consisting of representatives of the Cooperative Fuel Research Committee, the American Petroleum Institute, and Technical Committee A, organized to recommend a method of financing research on allowable sulfur limits in gasoline.

The Section on Vapor Lock (G. G. Brown, chairman) has endorsed the Tentative Method of Test for Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 31 T) as the best means now available for measuring vapor-lock tendencies of motor fuels and has compiled data on vapor pressure of motor fuels in relation to their performance. This investigation is being continued.

The Section on Detonation (T. G. Delbridge, chairman), newly organized during the year, had proposed as tentative a method of test for determination of knock characteristics of motor fuels, based on the apparatus and procedure developed by the Cooperative Fuel Research Committee. Pending further correlation of the results obtained by this method with the behavior of motor fuels in service, it has been decided to defer the recommendation of this method to the Society as a tentative standard and to print the method at this time for information only. The proposed method appears as Appendix II to this report.

Respectfully submitted on behalf of the technical committee,

H. L. Horning,
Chairman.

T. G. Delbridge,
Secretary.

APPENDIX I

REPORT OF SECTION ON GUM IN GASOLINE

The problem of gumming of gasoline has received much attention by various investigators during the past few years. It is well established that gum formation is due to oxidation of certain constituents of the gasoline resulting, by subsequent polymerization or otherwise, in formation of non-volatile compounds, which upon evaporation are deposited as resinous or varnish-like materials. The fact that the deposition of such material in the intake and manifold system of an engine using gasoline containing gum may seriously interfere with the functioning of the engine leads to the desirability of developing methods of test and specifications which will insure avoidance of gum troubles.

There is considerable evidence that gum deposition in an engine is a function of the amount of gum previously formed in the gasoline, and not a result of oxidation of the gasoline in the induction system. It has been shown that the gasoline engine will tolerate a certain gum content, sometimes called preformed gum, and various methods have been proposed for its determination. Another question of fundamental importance is the susceptibility of the gasoline to oxidation or, in effect, its rate of gum formation in storage prior to use.

The work of this section, therefore, falls naturally into the following three divisions:

1. Determination of gum content;
2. Tolerance of engines for preformed gum;
3. Determination of stability of gasoline as a means of predicting its rate of gum formation in storage.

DETERMINATION OF GUM CONTENT

Of the various methods proposed for determining gum content, practically all involve evaporation of the gasoline in some manner intended to prevent further oxidation. The steam-oven method, proposed by Cooke[1] and used extensively by the U. S. Bureau of Mines, excludes air by evaporation in a closed oven through which steam is passed. In the air-jet method, proposed by Hunn, Fisher and Blackwood,[2] oxidation is practically precluded by the rapidity with which evaporation takes place. A variation of this method, in which the gasoline is allowed to drip into a dish on a steam bath has been proposed by the same investigators. Quite recently the General Motors Laboratory has developed a high-temperature air-jet method in which the dish is placed on a bath of boiling ethylene glycol.

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[1] Cooke, "A Convenient Method for Determining Gum-Forming Material in Gasoline," U. S. Bureau of Mines *Serial No. 2686* (1925).

[2] Hunn, Fisher and Blackwood, "Gum in Gasoline," *Journal*, Soc. Automotive Engrs., Vol. 26, p. 31 (1930).

Each of these methods has been studied in a series of cooperative tests. Work was discontinued on the drip method after it was demonstrated that it gave results in substantial agreement with the air-jet method, since it appeared to offer no appreciable advantage over the latter. The steam-oven method has in most laboratories been used at temperatures above 100° C. and tests were initially run at 163 and 120° C. It was found that for a given sample higher results were obtained at the lower temperature of test. For gum values that were not excessively high, the steam-oven method at 163° C. appeared to yield results about one-half of those by the air-jet method, although this ratio varied considerably with the gum content of the sample. There were many discrepancies in results obtained in different laboratories by the steam-oven method. Results for samples of low gum content were particularly erratic and altogether this method did not seem sufficiently promising to justify further study as it appeared that the method would be difficult to standardize.

This comparative testing program, as well as published work, indicates that the amount of residual gum obtained from an aged or oxidized gasoline depends upon the conditions of evaporation, namely, temperature, rate, volume, etc. The problem, therefore, is the development of a test which will give results which are reproducible and of practical significance in performance.

The study of the 100° C. air-jet method has included such factors as temperature, time of drying after evaporation, volume of gasoline to be used, and weighing errors. A drying period of 1 hour at 155° C. was found to give substantially constant weight, while a volume of 50 ml. was chosen as most practicable. Errors in weighing the dishes, due to adsorbed moisture, appear to be important when low gum contents are involved. The use of a tare serves to minimize this error. In spite of efforts to attain reproducibility the results of cooperative tests indicate that errors of about ±2 mg. with gum contents in the range of 10 to 20 mg. per 100 ml. represents the accuracy of this method. However, it is believed that it is satisfactory for practical purpose.

The hot air-jet method, involving evaporation at a temperature of from 180 to 190° C., has the advantage of rapidity since the gum is dried for a few minutes on the evaporating bath. Due to the higher temperature the observed gum content is about one-half that found by the 100° C. method. This is somewhat of a disadvantage when low gum contents are concerned. Table I shows the results of cooperative tests on three samples by the two air-jet methods, hereafter called air-jet methods *A* and *B* and which appear at the end of this report. It should be pointed out that this represents the first set of cooperative tests using Method *B*, tetralin being used as the bath liquid. Subsequent investigation has shown that ethylene glycol is to be preferred. The results vary only slightly over the temperature range involved in this change. Results are also available showing the variation of the result with the air rate, indicating a rate of 0.85 to 1.15 liters per second as the optimum.

TABLE I.—AVERAGE RESULTS, GUM CONTENT, MG. PER 100 ML.

	METHOD *A* (100° C.)			METHOD *B* (190° C.)		
LABORATORY	SAMPLE D	SAMPLE E	SAMPLE F	SAMPLE D	SAMPLE E	SAMPLE F
No. 1	15.5	17.5	7.1	7.6	10.1	4.5
No. 2	11.1	16.6	6.5	4.3	9.9	3.9
No. 3	10.1	21.4	6.1	7.7	7.9	3.6
No. 4	11.7	15.9	4.7	...	....	...
No. 5	13.8	23.2	8.1	1.9	8.2	4.2
No. 6	15.9	15.1	6.4	9.2	8.8	5.1
No. 7	13.6	17.3	7.7	4.8	11.1	5.1
No. 8	11.9	18.1	7.2	4.6	9.5	4.7
No. 9	10.8	16.3	5.7	7.1	13.0	5.9

Descriptions of Methods *A* and *B* are included at the end of this report. Work is being continued with the expectation of adopting one or the other as a standard test.

GUM TOLERANCE

The data available on gum tolerance may be briefly summarized as follows:

A paper by Voorhees and Eisinger[1] gives results of operation of a Delco engine on gasolines with various gum contents, as determined by the 163° C. steam-oven test. In addition to certain fundamental findings mentioned in this introduction, their conclusion was that a gum content of 10 mg. by that method was near the limit of tolerance. From comparative tests obtained by the section, it seems that this value would be about 20 mg. by air-jet method *A*.

The Standard Oil Development Co.'s laboratories have contributed an extensive amount of work on gum tolerance, including block tests and road tests. Their results pointed to 10 mg. by the air-jet method *A* as about the limit of tolerance for multi-cylinder engines.

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[1] *Journal*, Soc. Automotive Engrs., Vol. XXIV, p. 584 (1929); also *Bulletin*, Am. Petroleum Inst., Vol. 9 (1928).

The Standard Oil Co. of New York has reported tests on a Delco engine and on a six-cylinder engine. The method of test for gum content was steam-bath evaporation with subsequent drying for 1 hour at 100° C., which would be expected to give appreciably higher results than the air-jet method *A*. The tolerance indicated was somewhere between 13 and 32 mg. per 100 ml. It was further found that gasoline containing as high as 50 mg. of polymers (from vapor-phase clay treatment) had little effect on the engine.

Data submitted by The Pure Oil Co. indicate somewhat higher tolerances, even as high as 75 mg., using a method somewhat similar to the preceding. No upper limit of tolerance was arrived at and the method of test has not been definitely correlated with that used by the section.

Other information, mainly individual tests, has been transmitted to the section. These observations serve mainly to show the harmful effect of high gum contents. A result obtained by The Atlantic Refining Co. indicates no harmful effects after long operation with a gasoline containing 29 mg. of gum by the steam-oven method at 177° C. Other data on tolerance have been expressed in terms of the copper-dish test, which makes the data almost valueless for conclusions regarding the effect of gum content.

Practical considerations indicate that the lowest indicated tolerances are of greater weight, since it is desired to arrive at a conclusion as to how much gum can be tolerated under practically all conditions. With this background the section has carried out cooperative tests with two gasolines, one containing 20 mg. and the other 10 mg. of gum per 100 ml. by Method *A*. The gasoline was prepared by blending a gasoline of high gum content with a stable gasoline of zero gum content, resulting in products which were quite stable over several months' time.

These test gasolines were run in four cars under ordinary driving conditions. The results naturally varied with the type of car. With two of the cars definite evidence of interference with operation, sticking of valves, was observed after 1000 to 1500 miles on the gasoline containing 20 mg. of gum. The other cars showed gum deposits in the intake system and on the valves after operation for 1500 to 2000 miles, so that all tests led to the conclusion that the amount of gum was above that permissible in practice.

Tests on the sample containing 10 mg. of gum showed much less evidence of gum deposition, much less than half that obtained in the preceding tests. With the car most sensitive to gum there was no interference with operation after 2500 miles and there were only minor evidences of gum deposition. In the other cars the gum deposited varied from none to slight evidences, after 2500 to 3000 miles of operation.

Pending further test work with other gasolines containing gum of this order of magnitude no final conclusions as to permissible gum content can be drawn. It should be borne in mind that, while test runs of more than about 3000 miles have been impractical, a proper specification for gum content should consider the possible results of at least 10,000 miles of operation.

As bearing on the question of the gum content of gasolines now on the market, the results of the U. S. Bureau of Mines 23rd Semi-Annual Motor Gasoline Survey[1] show that only 4 samples, out of 312 samples tested, had a gum content over 10 mg. by the Bureau of Mines' method. From an exchange of test samples with the Bureau, for correlation purposes, it is indicated that the gum content by the Bureau's method of the 23rd survey (100° C.) is approximately 50 per cent higher than by air-jet method *A*.

GUM STABILITY

Work has only recently been started on gum stability. Aside from the copper-dish test, the methods generally in vogue in the industry are all based on the same principle—accelerated oxidation generally at 100° C. in a closed container, with observations either as to pressure drop or gum formation after a definite time, or both. The method in most common use involves a metal bomb with an initial pressure of 100 lb. However, the conditions vary somewhat in the different laboratories and recent comparative tests obtained by the section show only qualitative agreement in results.

Recent findings at the U. S. Bureau of Standards show that results by the metal-bomb test, as ordinarily used, require a considerable correction on account of the time lag before the gasoline sample comes to the temperature of test. The only present method which is not subject to this criticism is the Voorhees test[2] which uses low pressure, a glass apparatus and shaking. The latter method involves fragile apparatus and has been used much less in the industry than the metal bomb.

After careful consideration of available methods it is believed that none of the present methods is in suitable shape for an immediate comparative and cooperative test program. The Bureau of Standards is now carrying on an intensive study of stability test methods with the support of the Cooperative Fuel Research Committee and it is planned to utilize those developments as soon as available.

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[1] U. S. Bureau of Mines *Report of Investigations No. 3152*, Part III.

[2] *Loc. cit.*

PROPOSED METHODS FOR DETERMINATION OF GUM CONTENT (PREFORMED GUM) IN GASOLINE

Method A

1. ***Apparatus.***—The apparatus shall consist of the following:

(*a*) *Dish.*—Flat-bottom glass dish of heat-resistant glass, 80 to 90 mm. in diameter at the top, 45 to 50 mm. in depth, and approximately 50 mm. in diameter at the bottom.

(*b*) *Steam Bath.*—The design of steam bath is optional. It should be provided with holes of such size that the dishes will be immersed to a point from 1 to 2 cm. from the top.

(*c*) *Air Supply.*—Low-pressure air, passing through cotton or glass-wool filter to a glass delivery tube ½ in. inside diameter. A flow meter or other air-measuring device shall be provided.

2. *Procedure.*—The dish shall be washed free from gum with benzol-alcohol, soaked in chromic-acid cleaning solution, rinsed with water and dried in an oven for 20 minutes at a temperature of from 300 to 310° F., after which it shall be allowed to cool for at least one hour in a desiccator. If the air in the balance to be used is dried with a desiccant then this same desiccant shall be used in the desiccator; otherwise no drying agent shall be used in the desiccator. The dish shall then be weighed, all weighings being made by tare against a similar dish which has been subjected to exactly the same treatment (omitting the gasoline) at exactly the same time as the test dish. The same dish may be used as a tare for more than one test dish, but not for more than six test dishes provided all are heated at the same time. Strict attention shall be given to these details of weighing in order to provide the accuracy necessary when low gum contents are involved.

After weighing, the dish shall be placed on the actively boiling steam bath, the other openings of the bath being kept loosely closed. A 50-ml. sample of gasoline shall then be poured into the dish and the air jet placed vertically above the center of the surface of the gasoline, the outlet being 2 to 4 in. above the surface of the liquid. The rate of air flow shall be adjusted so that, without causing loss of liquid by splashing or creeping, evaporation to "dryness" is completed in 10 to 20 minutes. To satisfy these conditions the air rate shall be 1 liter per second, ± 25 per cent. During the evaporation, the air rate and the height of the outlet may be adjusted within the specified limits to facilitate completion of the evaporation in the required time.

After the evaporation, the outside of the dish shall be wiped dry and examined for evidence of loss by creeping, any test which shows evidence of such loss being rejected. The dish shall then be dried in an air oven at a temperature of from 300 to 310° F. for exactly 1 hour. The dish shall then be allowed to cool for at least 1 hour in the desiccator and weighed as described above.

3. *Results.*—Results shall be expressed in milligrams of gum per 100 ml. of gasoline.

Method B

4. *Apparatus.*—The apparatus shall consist of the following:

(*a*) *Beaker.*—Berzelius-type beaker of heat-resistant glass, without lip, of 100-ml. nominal capacity.

(*b*) *Bath.*—The bath shall be in accordance with the design shown in Fig. 1. About 800 ml. of ethylene glycol, having a boiling point between 195 to 200° C., shall be used as the bath liquid. The bath shall be fitted with a reflux condenser at the top of which a drying tube containing calcium chloride shall be connected. The bath shall be insulated with asbestos paper. An electric hot plate capable of keeping the liquid boiling actively is the preferred heating means. In the absence of a satisfactory hot plate the bath may be heated by a gas burner in which case the apparatus should be placed in a hood with a good draught.

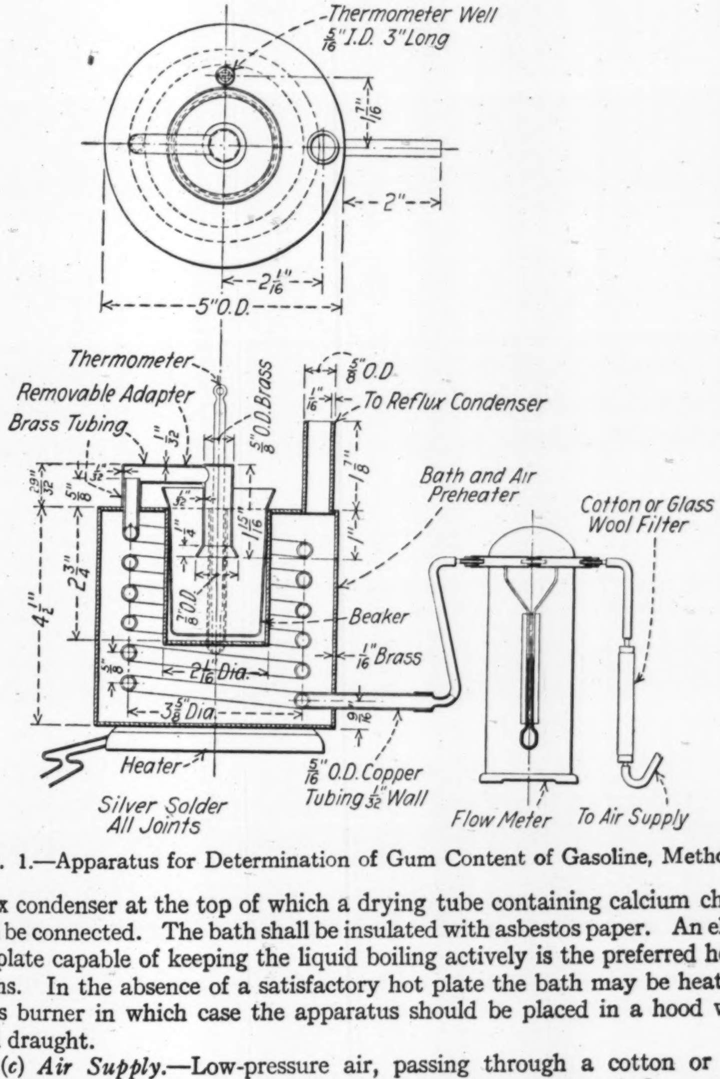
Thermometer Well
5/16" I.D. 3" Long
1 7/16"
2"
2 1/16"
5" O.D.
Thermometer
Removable Adapter
Brass Tubing
1/32"
5/8" O.D. Brass
5/8" O.D
1/16"
To Reflux Condenser
1 7/8"
29/32"
5/8"
1/32"
1/32"
1 15/16"
1/4"
1"
4 1/2"
2 3/4"
7/8" O.D.
Bath and Air Preheater
Cotton or Glass Wool Filter
Beaker
1/16" Brass
2 1/16" Dia.
5/8"
3 5/8" Dia.
9/16"
Heater
5/16" O.D. Copper Tubing 1/32" Wall
Silver Solder All Joints
Flow Meter
To Air Supply

FIG. 1.—Apparatus for Determination of Gum Content of Gasoline, Method B.

(*c*) *Air Supply.*—Low-pressure air, passing through a cotton or glass-wool filter and delivered to the preheater inlet of the bath. A flow meter or other air-measuring device shall be provided as shown in Fig. 1. (Flow meter is not drawn to scale.)

5. *Procedure.*—The beaker shall be washed free from gum with benzol-alcohol, soaked in chromic-acid cleaning solution, washed with water, dried with a lint-free cloth and, while held with tongs, dried in the free flame of a Bunsen burner, after which it shall be allowed to cool for at least one hour in a desiccator. If the air in the balance to be used is dried with a desiccant then this same desiccant shall be used in the desiccator; otherwise no drying agent shall be used in the desiccator. The beaker shall then be weighed, all weighings being made by tare against a similar beaker which has been subjected to exactly the same treatment (omitting the gasoline) at exactly the same time as the test beaker. The same beaker may be used as a tare for more than one test beaker but not for more than six test beakers provided all are heated at the same time. Strict attention shall be given to these details of weighing in order to provide the accuracy necessary when low gum contents are involved.

After weighing, the beaker shall be placed in the well of the bath as shown in Fig. 1. The air flow shall be adjusted to a rate of 1 liter per second, ± 15 per cent. The bath shall then be heated so that the temperature of the effluent air, measured by a thermometer placed on the bottom of the beaker at the center, shall be from 180 to 190° C. This is governed largely by the rate of boiling of the bath liquid and the rate of air flow.

The metal adapter shall be removed and 50 ml. of the gasoline poured into the beaker after which the adapter shall be replaced on the air outlet so that it is vertically above the center of the surface of gasoline. After the gasoline has evaporated, which should require from 5 to 10 minutes, the beaker shall be left in place for an additional 15 minutes, the air supply being maintained. The beaker shall then be allowed to cool for 1 hour in the desiccator and weighed as described above.

6. *Results.*—Results shall be expressed in milligrams of gum per 100 ml. of gasoline.

APPENDIX II

PROPOSED METHOD FOR DETERMINATION OF KNOCK CHARACTERISTICS OF MOTOR FUELS[1]

This method is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee, composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers, and U. S. Bureau of Standards, who have been studying this problem since 1928.

> Committee D-2 on Petroleum Products and Lubricants indorses the C.F.R. engine for measuring octane numbers of motor fuels. Procedure conditions such as engine speed and operating temperature are being studied by the detonation subcommittee of the Cooperative Fuel Research Committee in conjunction with road tests. It is expected that results of this work will permit establishment of an A.S.T.M. tentative standard in the near future. No changes in engine design are anticipated.

Scope. 1. This method is intended for determining the knock characteristics, in terms of an arbitrary scale of octane numbers, of gasolines and equivalent fuels for use in spark-ignition engines, other than engines for aircraft.

Octane Number. 2. The octane number of a motor fuel is the whole number nearest to the octane number (Note 1) of that mixture of *iso*octane with normal heptane or "one-degree" (Note 2) benzene which the motor fuel matches in knock characteristics when compared by the procedure specified herein.

NOTE 1.—Octane number is defined by and is numerically equal to the percentage by volume of *iso*octane (2, 2, 4-trimethylpentane) in a mixture of *iso*octane and normal heptane, used as a primary standard for measurement of knock characteristics. Octane numbers above 100 are expressed numerically as 100 plus the percentage by volume of "one-degree" benzene (C_6H_6) in a mixture of *iso*octane and benzene. Thus, by definition, normal heptane has an octane number of zero; *iso*octane has an octane number of 100; and benzene has an octane number of 200.

NOTE 2.—"One-degree" benzene[2] is a commercial product conforming to the following requirements:

(*a*) boiling range not greater than 1° C., embracing the boiling point of chemically pure benzene;

(*b*) specific gravity of from 0.882 to 0.886, when determined in accordance with the Tentative Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 - 32 T) of the American Society for Testing Materials.[3]

(*c*) free from hydrogen sulfide, carbon disulfide and thiophene;

(*d*) free from turbidity, with color not darker than a solution of 3 mg. potassium dichromate in 1 liter of water when compared in 50-cc. Nessler tubes.

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[1] Criticisms of this Proposed Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

[2] "One-degree" benzene may be procured from The Barrett Co., 40 Rector St., New York City.

[3] See p. 757.

Apparatus. 3. The knock-testing unit described in this section must be used without modification. The apparatus shall consist of a continuously-variable-compression engine, together with suitable loading and accessory equipment as follows:

(*a*) *Engine.*—Continuously variable compression, one-cylinder, with dimensions as follows:

Bore, in	3.25
Stroke, in	4.50
Displacement, cu. in	37.4
Valve diameter, in. clear	1.1875
Connecting-rod bearing:	
diameter, in	2.25
length, in	1.625
Front main bearing:	
diameter, in	2.25
length, in	2.00
Rear main bearing:	
diameter, in	2.25
length, in	4.25
Piston pin, floating, diameter, in	1.25
Connecting rod, center to center, in	10.00
Timing gear face, in	1.00
Piston rings, number	5
Exhaust pipe, diameter, in	1.25
Spark plug, size, mm	18.00
Weight of engine, lb. (approx.)	475
Weight of complete unit, lb. (approx.)	1375

(*b*) *Crankshaft.*—Fully machined, heat treated, and counterbalanced.

(*c*) *Crankcase.*—Case iron, with rigid end walk.

(*d*) *Connecting rod.*—Rifle-drilled, S.A.E. No. 1045 steel, heat-treated, bearing alloy cast directly into big end.

(*e*) *Main Bearings.*—Renewable sleeve bushings, babbitt-lined.

(*f*) *Valves.*—Silcrome.

(*g*) *Push rods.*—Mushroom type with lock-nut adjustment.

(*h*) *Cylinders.*—Cast of iron alloy, bored and honed, Brinell hardness, 200 to 210.

(*i*) *Cylinder head.*—Integral with cylinder.

(*j*) *Cooling system.*—Evaporatively cooled, with positive pump circulation.

(*k*) *Lubrication.*—Pressure feed to main connecting-rod, piston-pin, and camshaft bearings, and to idler gear stud and gears.

(*l*) *Oil Heater.*—Electric heater in base brings oil to operating temperature quickly.

(*m*) *Ignition.*—May be either a coil, condenser, and contactor system or a magneto. A neon-tube spark indicator is built into the engine. Spark advance is automatically adjusted to maximum power as the compression ratio is changed.

(*n*) *Carburetor.*—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or four float-bowls. The carburetor has a fixed fuel jet, shrouded by a variable air jet. Fuel containers are furnished with the carburetor.

(*o*) *Instruments.*—Knock intensity is measured by a bouncing pin, in conjunction with either a gas-evolution burette or a knockmeter. The gas-evolution burette is an electrolytic cell, which integrates the impulses of current through the bouncing-pin circuit and indicates the total by the volume of gas collected in the burette in a given time. The knockmeter is a hot-wire ammeter which averages the flow of current in the circuit, so that readings over a fixed period of time are unnecessary. Current for operation of the bouncing-pin is supplied from a small direct-current generator, belt-driven from the power absorbing unit.

(*p*) *Power Absorbing Unit.*—The engine is connected by V-type belts to an electric generator. This preferably should be an induction motor with synchronous characteristics, but may be any electric generator capable of maintaining proper operating conditions. In most cases the electric generator will act as a starting motor to crank the engine, but if a direct-current generator is used, and no outside source of current is available, the engine may have to be cranked by hand.

(*q*) *Complete Unit.*—The complete unit may be obtained with the engine, generator, and panel board mounted on a cast-iron base plate. All necessary instruments and accessories are furnished with the unit.

Standard Requirements.

4. The engine shall be run with the following standard requirements:[1]

(*a*) *Engine Speed.*—600 r.p.m. ± 2 r.p.m.

(*b*) *Jacket Temperature.*—Constant within ± 1° F. and at a temperature between the limits of 205 and 215° F. (96 and 102° C.).

(*c*) *Cooling Liquid.*—Distilled water, rain water, or ethylene-glycol solution when necessary at high altitude.

(*d*) *Crankcase Lubricating Oil.*—S.A.E. Viscosity No. 20.

NOTE.—The viscosity range of crankcase lubricating oil, S.A.E. Viscosity No. 20 is from 120 to 185 seconds when determined on the Saybolt universal viscosimeter at 130° F., in accordance with the Standard Method of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[2]

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[1] The C.F.R. engine as supplied for test purposes has no throttle. Therefore, all tests must be carried on at what corresponds to full throttle opening.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 550.

(*e*) *Valve Clearances.*—Intake 0.008 in., cold; exhaust 0.010 in., cold.

(*f*) *Spark Advance.*—For maximum power, automatically controlled:

22.5 deg. at 5:1 compression ratio (basic setting);
18 deg. at 6:1 compression ratio;
15 deg. at 7:1 compression ratio.

(*g*) *Breaker-Point Clearance.*—Battery system 0.015 in.; magneto 0.020 in.

(*h*) *Spark Plug.*—Shall conform to the standard metric plug having the tolerances and thermal characteristics equal to the No. 8 spark plug furnished by the Champion Spark Plug Co., Toledo, Ohio.

(*i*) *Spark-plug Gap.*—0.025 in.

(*j*) *Carburetor Adjustment.*—For maximum knock.

(*k*) *Compression Pressure.*—Between 98 lb. and 102 lb. at 5:1 compression ratio.

Foundation.

5. The foundation shall be of concrete and at least 18 in. high. If possible, it should be prepared by pouring on a concrete floor. Proper dimensions will be furnished with the engine. For convenience in operation, the foundation should be placed at least 2 ft. from any wall. Should the floor of the building on which the engine is to be installed be other than portland-cement concrete, the floor should be cut away so that the engine foundation will rest directly on the ground. In such case the bearing area of the foundation will depend upon the condition of the underlying soil, and should be such as to give ample footing.

Reference Fuels.

6. *Primary Reference Fuels.*—The primary[1] reference fuels shall be *iso*octane (2, 2, 4-trimethylpentane), normal heptane (Note 1) and "one-degree" benzene. Normal heptane and *iso*octane shall be certified for suitability as primary reference fuels by the U. S. Bureau of Standards (Note 2).

NOTE 1.—*Secondary Reference Fuels.*—Mixtures of normal heptane and *iso*octane required for referee testing are expensive. For this reason secondary reference fuels may be used for routine determinations.[2] Such secondary reference fuels may be straight-run or other stable gasolines suitable for the purpose. One of the reference fuels should be of low knock rating and the other of high knock rating, or if a sufficiently high knock rating fuel is not available, a mixture of the higher knock rating fuel plus a knock suppressor may be used. These secondary reference fuels shall be calibrated on the octane-number scale against normal heptane and *iso*octane sufficiently often to insure accuracy of calibration; and for every case, whether a fuel is rated by secondary reference fuels or by means of normal heptane and *iso*octane, the result shall be recorded as an octane number.

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[1] At present, *iso*octane may be obtained from Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa., and normal heptane from the California Chemical Co., 111 Sutter St., San Francisco, Calif.

[2] Recently three secondary reference fuels have become commercially available through the Standard Oil Company of New Jersey. These fuels have octane numbers of approximately 48, 68 and 76, respectively, and calibration curves are furnished with them as determined in accordance with this method, giving octane numbers for these fuels blended with each other and with benzene and tetraethyl lead. They may be ordered through Mr. Ross H. Dickson, Standard Oil Development Co., Room 734, 26 Broadway, New York City.

NOTE 2.—For the present this certification consists of tests made by the Bureau of Standards on each batch of normal heptane or *iso*octane prepared respectively by the two companies mentioned above, with certificates issued to these companies authorizing them to guarantee to the purchaser that the material shipped is a part of a batch so tested and to quote the results of the Bureau of Standards' tests.

Starting and Stopping the Engine.

7. While the engine is being turned over the ignition shall be turned on and the carburetor set so as to draw fuel from one float bowl. To stop the engine the fuel and the ignition switch shall be turned off and then the motor shall be stopped by means of the push-button switch. To avoid corrosion of valves and seats, the engine shall be turned over by hand until both valves are closed.

Outline of Procedure.

8. The octane number of a fuel shall be ascertained by comparing the knock intensity for the fuel with those for various blends of the reference fuels until two blends differing in knock rating by not more than two octane numbers are found, one of which gives a higher knock intensity than the fuel and the other a lower knock intensity. The knock intensity shall be measured by a bouncing-pin indicator in conjunction with either a gas-evolution burette or a knockmeter.[1]

Before the test sample and the blends of the reference fuels can be compared, the compression ratio must be set to give the proper knock intensity and the carburetor adjusted to give the maximum knock for each fuel.

Preliminary Adjustment of Compression Ratio.

9. Using a mixture of 70 parts of *iso*octane and 30 parts of normal heptane, the compression ratio shall be raised until a knock first becomes audible. The compression ratio at this point shall be increased by one unit and the numerical indication of knock intensity obtained from the gas-evolution burette or from the knockmeter, whichever is used, shall be recorded. This procedure is necessary for the first adjustment only. For subsequent tests on fuel samples the compression ratio shall be set to duplicate this knock intensity, as indicated by the gas-evolution burette or the knockmeter, provided no change has been made in bouncing-pin adjustment in the meantime. In no case shall the knock intensity be such that the engine does not cease firing when ignition is interrupted.

Adjustment of Carburetor for Fuel Under Test.

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows:

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[1] The gas evolution burette is less expensive than the knockmeter, but requires more time in making tests.

(*a*) *By Gas-evolution Burette.*—At least two readings, agreeing within 5 per cent, of the volume of gas evolved over a period of 1 minute shall be taken as a measure of knock intensity. After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by noting the gas evolution and the micrometer setting, then turning the micrometer screw and noting whether the gas evolution increases or decreases. The micrometer shall then be turned in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the micrometer set at the position of maximum knock.

(*b*) *By Knockmeter.*—When using the knockmeter it is unnecessary to take readings over a fixed period of time, but the knockmeter needle shall be allowed to reach equilibrium after each adjustment of the micrometer. The carburetor shall be adjusted to the maximum knock position in a manner similar to that described in Paragraph (*a*) by turning the micrometer and noting the knockmeter readings.

Final Adjustment of Compression Ratio.

11. Finally, adjust the compression ratio to give the same reading on the gas-evolution burette or the knockmeter when using the fuel under test as was obtained in the first adjustment under Section 9.

12. A trial blend[1] of the low octane-number reference fuel and the high octane-number reference fuel, based on the expected knock rating of the fuel sample under test, shall be placed in another carburetor float bowl and the engine run on this trial blend. The micrometer of this float bowl shall then be adjusted to the maximum knock position in a manner similar to that described in Section 10 (*a*) or (*b*).

Octane Number Determination.

13. With the carburetor micrometers set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. When using the gas-evolution burette, at least two successive 1-minute readings shall agree within 5 per cent. When using the knockmeter, the needle shall be allowed to reach equilibrium before the final reading is recorded.

At least three alternate series of readings shall be taken on each fuel. After changing from one fuel to another, at least 1 minute shall be allowed for the engine to reach equilibrium. With some fuels an appreciably longer time interval may be required. If the average knock intensity of the fuel sample is higher than the average of the reference-fuel blend, the test shall be repeated with a blend containing a decreased proportion of the high octane-number reference fuel.[2]

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[1] Extreme care is required to insure thorough mixing of the ingredients.

[2] When changing fuels in the containers, the fuel in the container shall be drained completely by means of the drain-cock provided. A small portion of the new fuel shall be allowed to flow through the line before closing the drain-cock.

The test shall be continued in this manner until the knock intensity for the fuel sample is definitely higher than one blend and lower than another blend of the reference fuels. The difference between these two final reference-fuel blends shall be not more than two octane numbers.

Calculation.

14. The knock rating of the fuel sample shall be obtained by interpolation from the figures so recorded and shall be reported as the nearest whole octane number.

Accuracy.

15. Values determined by this procedure with different C.F.R. engines and in different laboratories shall differ by not more than two octane numbers.

While the accuracy of this method is as above stated, its sensitivity may permit detection of differences as small as 0.2 octane number when alternate readings of knock intensity are taken on the two fuels as directed in Section 13.

Maintenance.

16. It is recommended that a systematic inspection of the testing apparatus be carried out with the utmost care after each 50-hour operation. The following points should be emphasized:

(*a*) *Bouncing Pin.*—Irregular gas evolution or lack of sensitivity may indicate diaphragm trouble. Diaphragm retaining nut should be tightened and any carbon accumulation removed. If this does not correct the condition, the diaphragm may have deteriorated and may need to be replaced.

(*b*) *Breaker Points.*—If necessary, pits should be removed and breaker-point clearance adjusted.

(*c*) *Spark Plugs.*—The porcelain should be carefully inspected for cracks, and defective plugs replaced. The spark gap should be carefully checked and adjusted if necessary. When plugs are re-used any carbon deposit on the metal body of the plug or on the electrodes should be removed mechanically before making gap adjustments.

(*d*) *Fuel System.*—Any foreign matter which may have accumulated in the fuel containers, float bowls, lines, or carburetor should be removed. Blowing with air and then flushing the fuel system with gasoline or benzol is a convenient method.

(*e*) *Cooling System.*—Any leaks revealed by inspection should be repaired and the pump packing tightened or replaced as required.

(*f*) *Combustion Chamber.*—Carbon deposits should be removed by scraping or polishing.

(*g*) *Compression Pressure.*—The cause of any abnormal change between inspections should be investigated and corrected.

(*h*) *Valves.*—Valves should be removed and re-ground unless there is a continuous polished line of contact on both the valve and the valve seat. After re-assembling, the valve-tappet clearances should be carefully adjusted.

REPORT OF TECHNICAL COMMITTEE C ON FUEL OILS (INCLUDING DIESEL FUEL)

Technical Committee C on Fuel Oils (Including Diesel Fuel)[1] is so organized as to provide adequate representation from all groups interested in fuel oils. The scope of Technical Committee C as finally approved is as follows:

SCOPE: The preparation of specifications for fuel oils of flash point with Tag closed tester not less than 100° F. when used for fuel purposes in domestic, industrial, or marine burners, or in Diesel engines. Kerosine is specifically excluded.

Arrangements are under way to insure that guarantee tests on fuel oil burners conducted by the Underwriters' Laboratories, Inc., or others, shall be carried out in the future with fuel oils corresponding to the limits for the respective grades as given in the Commercial Standard CS 12 – 29 for Domestic and Industrial Fuel Oils.

Arrangements have been consummated to interchange information on Diesel fuel specifications with the British Standards Institution.

Section I on Domestic and Industrial Fuel Oil (L. P. Smith, chairman) is reporting the results of its questionnaire on the present commercial standard specifications (CS 12 – 29) for consideration at the June 21 meeting. Section I is making a study of carbon residue of fuel oils with the cooperation of Subcommittee XXIII on Carbon Residue, of Committee D-2.

Section II on Diesel Fuel Oils (L. H. Morrison, chairman) reports that an extensive series of tests on fuel oils in Diesel engines will be run at the U. S. Submarine Base at New London, Conn.; also that the Society of Automotive Engineers' Research Committee is cooperating on work upon light-weight, high-speed Diesel engine fuels.

Diesel fuel research work is in progress at Massachusetts Institute of Technology, Pennsylvania State College and Iowa State College and by the National Automobile Chamber of Commerce.

Diesel engine fuel oil tests have been completed and reported upon by one Diesel engine builder and are still in progress with another.

Respectfully submitted on behalf of the technical committee,

LEE SCHNEITTER,
Chairman.

A. E. FLOWERS,
Secretary.

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[1] The personnel of the Technical Committee is identical with that of the American Standards Association Sectional Committee on Fuel Oils (Including Diesel Fuels).

REPORT OF COMMITTEE D-4
ON
ROAD AND PAVING MATERIALS

Since the reorganization of Committee D-4 on Road and Paving Materials in 1931, a number of its new subcommittees have started systematic programs of cooperative work, but these studies have not as yet progressed sufficiently to formulate definite recommendations which could be transmitted to the Society. The work of Subcommittee B-6 on Extraction of Bituminous Aggregates (J. S. Miller, chairman) has, however, produced results which the committee feels are of such value as to warrant publication. A report of this subcommittee is, therefore, appended to this report.

Committee D-4 wishes to go on record as approving the proposal of Committee D-2 on Petroleum Products and Lubricants to change one of its recommended temperatures in the operation of the Saybolt Furol Viscosimeter from "212° F." to "210° F."

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Tentative Methods of Chemical Analysis of Calcium Chloride.—The committee recommends for publication as tentative the proposed Methods of Chemical Analysis of Calcium Chloride which were published in its 1931 report as information.[1] No criticism of these methods which are appended hereto[2] has been received since their publication.

Tentative Method of Test for Consistency of Portland-Cement Concrete (D 138 – 26 T).[3]—In order to clarify the test procedure in this method of test for consistency of concrete and to harmonize this method with methods of test proposed by Committee C-9 on Concrete and Concrete Aggregates, the committee recommends that this method be revised as follows and continued as tentative:

Section 4.—Change from its present form: namely,

> 4. The mold shall be placed on a flat, non-absorbent surface, such as a smooth plank or a slab of concrete, and the operator shall hold the form firmly in place, while it is being filled, by standing on the foot pieces. The mold shall be filled to about one-fourth of its height with the concrete which shall then be puddled, using 25 strokes of a $\frac{5}{8}$-in. rod, 2 ft. long, bullet pointed at the

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 475 (1931).

[2] See p. 777.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 874 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 522.

lower end. The filling shall be completed in successive layers similar to the first and the top struck off so that the mold is exactly filled. The mold shall then be removed by being raised vertically, immediately after being filled. The molded concrete shall then be allowed to subside until quiescent and the height of the specimen measured.

to read as follows:

4. The mold shall be filled in three layers, each approximately one-third the volume of the mold. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mold as the concrete slides from it, in order to insure symmetrical distribution of concrete within the mold. Each layer shall be rodded with 25 strokes of a ⅝-in. rod, 24 in. in length, bullet pointed at the lower end. The strokes shall be distributed in a uniform manner over the cross-section of the mold and shall penetrate into the underlying layer. The bottom layer shall be rodded throughout its depth. After the top layer has been rodded the surface of the concrete shall be struck off with a trowel so that the mold is exactly filled. The mold shall be immediately removed from the concrete by raising it carefully in a vertical direction. The slump shall then be measured immediately by determining the difference between the height of the mold and the height at the vertical axis of the specimen.

Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18).[1]—In its 1931 report, Committee D-4 recommended revised definitions of the terms Bitumens, Asphalts, Flux, Tars, and Pitches which were accepted by the Society for publication as tentative revisions of the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18).[2] No criticism of the revised definitions has been received and the committee accordingly recommends that they be adopted as standard to replace definitions for the same terms in the present Standard Definitions D 8 – 18.

The results of the letter ballot of the committee upon the recommendations made in this report appear in the following table:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARD			
Tentative Methods of Chemical Analysis of Calcium Chloride	49	0	38
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Method of Test for Consistency of Portland-Cement Concrete (D 138 – 26 T)	55	0	32
III. ADVANCEMENT TO STANDARD OF TENTATIVE REVISION OF EXISTING STANDARD			
Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18):			
Definition of Term Bitumens	60	0	27
Definition of Term Asphalts	59	1	27
Definition of Term Flux	56	2	29
Definition of Term Tars	57	3	27
Definition of Term Pitches	58	2	27

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 673.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 477 and 1069 (1931).

This report has been submitted to letter ballot of the committee, which consists of 87 members; 69 members returned their ballots, of whom 61 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

P. J. FREEMAN,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Chemical Analysis of Calcium Chloride were accepted for publication as tentative and appear on page 777.

The proposed revision of the Tentative Method of Test for Consistency of Portland-Cement Concrete was accepted. The method in its revised form appears on page 775.

The tentative revisions of the definitions of the terms "bitumens," "asphalts," "flux," "tars," and "pitches," appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1932. The definitions of these terms in their revised forms appear in the 1932 Supplement to Book of A.S.T.M. Standards, page 80.

Subsequent to the annual meeting the committee approved proposed revisions of the Tentative Methods of Test for Ductility of Bituminous Materials and Test for Residue of Specified Penetration for submission to the Society through Committee E-10 on Standards. The revisions were accepted on August 11, 1932, by Committee E-10 and the methods in their revised form appear on pages 781 and 784, respectively.

REPORT OF SUBCOMMITTEE B-6 ON EXTRACTION OF BITUMINOUS AGGREGATES

The project assigned to the subcommittee is to determine the best method for the analysis of bituminous paving mixtures.

The subcommittee has endeavored to keep in mind the purpose of a standard method and, if possible, to have such a method applicable to routine testing. The length of time required to make the test, the amount of constant attention, and materials consumed were also factors that were considered but none of these should govern if they reduce the accuracy of the method.

While the assignment covers all classes of bituminous mixtures for highway purposes, the subcommittee has confined its attention to the fine aggregate type of mixture, such as sheet asphalt, for its first cooperative work.

The following is a complete list of the laboratories cooperating. In addition to its personnel, the subcommittee had the advantage of three other laboratories cooperating, namely, laboratories Nos. 3, 7 and 9:

No. 1—State of New Jersey State Highway Commission.
No. 2—Commonwealth of Pennsylvania Department of Highways.
No. 3—City of Rochester, N. Y., Department of Public Works.
No. 4—The Texas Company.
No. 5—The Barber Asphalt Company.
No. 6—Weiss & Downs, Inc., New York City.
No. 7—Chicago Testing Laboratory, Inc., Chicago.
No. 8—Stillman & Van Siclen, Inc., New York City.
No. 9—Milton Hersey Company, Ltd., Montreal, Canada.

The methods investigated included the thimble extraction apparatus as described in the Standard Methods of Testing Rubber Products (D 15 – 24) and referred to in Standard Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 – 27), and three other methods. These four methods are appended hereto as information. In addition, each cooperating laboratory was asked to use any other methods they had found satisfactory provided they furnished complete details of the methods.

Two different mixtures were prepared and every individual sample of each mixture was tested before releasing them to the members of the subcommittee in order to insure as uniform samples as possible. The only variable in the two mixtures was the character of mineral filler used. In one the filler was limestone dust and in the other portland cement.

TABLE I.—SUMMARY OF RESULTS ON MIXTURE NO. 1, OIL ASPHALT CEMENT, LIMESTONE DUST FILLER, BY VARIOUS EXTRACTION METHODS.

(Results expressed in percentage by weight.)

Laboratory	Size of Sample, g.	Centrifuge Tube Method			Dulin Rotarex Method			Barber Asphalt Method			Thimble Extraction Method			Miscellaneous Methods[a]		
		Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Special Size Sample, g.	Bitumen, per cent	Bitumen +200 Mesh, per cent
No. 1[c]	10........	10.10	...	...	10.83	...	...	10.26	...	...	10.20	...	...	10	10.13[b, d]	...
	50........	...	...	...	10.36	...	...	...	...	...	...	...	...	300	10.39[b]	22.69[e]
	50........	...	...	...	10.56	...	...	...	...	...	...	...	...	...	...	...
No. 2	25........	10.1	24.5	...	...	...	...	...	...	...	...	...	...	...	...	...
	100........	...	...	...	10.7[b]	23.4	...	...	...	...	...	...	...	...	...	...
No. 3	10........	10.16	21.30	0.84	12.86	24.00	0.54	10.22	23.00	0.78	10.38	24.00	1.79	...	...	...
	10........	10.85	22.60	0.35	13.03	23.70	0.48	10.23	23.10	0.70	10.40	22.80	1.52	...	...	...
	25........	10.60	23.72	0.44	11.03	23.56	0.94	...	...	...	10.74	23.80	1.29	...	...	...
	25........	10.04	23.36	0.75	11.27	23.36	0.78	...	...	...	10.16	23.68	1.48	...	...	...
	200........	...	...	...	10.81	22.10	2.31	...	...	...	...	...	...	...	...	...
No. 4	10........	...	...	...	...	...	...	...	...	...	10.42	20.94	1.35	15	10.52[b, f]	...
	25........	10.34	21.44	0.39	...	...	...	...	...	...	10.00	20.71	1.52	...	...	...
	25........	10.63	21.37	0.56	...	...	...	...	...	...	...	...	...	50	10.44	21.05[g]
No. 5	10........	...	...	...	...	...	...	10.2	23.0	0.82	10.3	22.0	1.37	...	...	...
	25........	...	...	...	...	...	...	10.1	22.4	0.74	10.5	22.5[j]	1.56	...	...	...
No. 6[i]	10........	...	...	...	10.94	19.84	0.106	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.48	20.19	0.302	...	...	...	...	...	...	...	...	...
	50........	...	...	...	10.55	21.26	0.648	...	...	...	...	...	...	...	...	...
No. 7	10........	10.3	23.5	...	...	...	...	...	...	...	10.4	...	...	10	10.2[h]	...
	10........	10.2[b]	23.0	...	...	...	...	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.4	...	...	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.2[b]	...	...	...	...	...	...	...	...	...	...	...
No. 8	25........	...	...	...	10.49	21.79	...	...	...	...	...	...	...	...	...	...
	100........	...	...	...	10.7[b]	22 3	...	...	...	...	...	...	...	...	...	...
No. 9	25........	...	...	...	...	...	...	10.4	24.0	...	...	...	...	...	...	...
Average............		10.33	22.75	0.56	10.95	22.31	0.76	10.24	23.10	0.76	10.35	22.55	1.49	...	...	...
Maximum Spread...		0.81	3.20	0.49	2.83	4.16	2.20	0.30	1.6	0.12	0.74	3.29	0.50	...	...	...

[a] No corrections given on any of the miscellaneous methods.

[b] In these tests carbon tetrachloride (CCl_4) was used instead of carbon bisulfide (CS_2) except that in the Dulin rotarex method laboratory No. 7 used mixture of CCl_4 and C_6H_6; also miscellaneous methods were in accordance with methods noted.

[c] Duplicate determination of bitumen.

[d] New Jersey State Highway laboratory rotarex method (Benzol, C_6H_6, used as solvent).

[e] Colonel J. W. Howard's method (carbon bisulfide, CS_2 + chloroform, $CHCl_3$, used as solvent).

[f] Procedure using C_6H_6 as in Standard Methods of Testing Rubber Products (D 15 - 24).

[g] Texas Co. special method.

[h] Soxhelt hot extraction method (Benzol, C_6H_6, used as solvent).

[i] Analyses do not add to 100 per cent.

[j] 20-g. sample.

The results submitted by the cooperating laboratories for all tests run on samples of the two mixtures are shown in Tables I and II. A study was made of the averages obtained from Tables I and II for the four principal methods, to determine: which method

TABLE II.—SUMMARY OF RESULTS ON MIXTURE NO. 2, OIL ASPHALT CEMENT, PORTLAND CEMENT FILLER, BY VARIOUS EXTRACTION METHODS.

(Results expressed in percentage by weight.)

Laboratory	Size of Sample, g.	Centrifuge Tube Method			Dulin Rotarex Method			Barber Asphalt Method			Thimble Extraction Method			Miscellaneous Methods^{a}		
		Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Bitumen, per cent	Bitumen +200 Mesh, per cent	Correction, per cent	Special Size Sample, g.	Bitumen, per cent	Bitumen +200 Mesh, per cent
No. 1^{c}	10........	10.46	...	...	10.82	...	...	10.52	...	...	10.23	...	...	10	10.68$^{b, d}$	...
	50........	...	...	...	10.63	...	...	...	...	...	...	...	...	300	10.73^{b}	22.7^{e}
	50........	...	...	...	10.77	...	...	...	...	...	...	...	...	...	...	...
No. 2	25........	10.2^{b}	25.3	...	...	...	...	...	...	...	...	...	...	...	...	...
	100........	...	...	...	10.9^{b}	23.7	...	...	...	...	...	...	...	...	...	...
No. 3	10........	10.55	23.10	0.65	10.81	23.60	1.01	10.29	23.30	1.22	10.47	22.60	1.30	...	...	...
	10........	10.34	23.10	0.36	12.85	23.40	0.51	10.29	23.40	0.97	10.21	23.60	1.50	...	...	...
	25........	10.60	23.56	0.65	11.69	23.44	0.77	...	...	...	10.38	23.56	1.40	...	...	...
	25........	10.41	23.16	0.31	12.16	23.48	1.13	...	...	...	10.38	23.76	1.55	...	...	...
	200........	...	...	...	10.54	21.73	2.72	...	...	...	...	...	...	...	...	...
No. 4	10........	...	...	...	...	...	...	...	...	...	10.21	21.18	...	15	10.68$^{b, f}$	...
	10........	...	...	...	...	...	...	...	...	...	10.11	21.17	...	...	...	...
	25........	10.30	20.67	0.74	...	...	...	...	...	...	...	...	...	50	10.90	21.06^{g}
	25........	10.50	20.75	0.40	...	...	...	...	...	...	...	...	...	...	...	...
No. 5	10........	...	...	...	...	...	...	10.2	23.0	1.04	10.5	22.0	1.48	...	...	...
	25........	...	...	...	...	...	...	10.3	22.4	0.49	10.5	23.0^{j}	1.69	...	...	...
No. 6^{i}	10........	...	...	...	10.59	20.86	0.156	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.73	23.38	0.196	...	...	...	...	...	...	...	...	...
	50........	...	...	...	10.65	23.07	0.488	...	...	...	...	...	...	...	...	...
No. 7	10........	10.6	24.2	...	...	...	...	...	...	...	10.7	...	...	10	10.5^{h}	...
	10........	10.6^{b}	23.5	...	...	...	...	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.6	...	...	...	...	...	...	...	...	...	...	...
	25........	...	...	...	10.6^{b}	23.2	...	...	...	...	...	...	...	...	...	...
No. 8	25........	...	...	...	10.67	21.67	...	...	...	...	...	...	...	...	...	...
	100........	...	...	...	11.2^{b}	22.50	...	...	...	...	...	...	...	...	...	...
No. 9 ..	25........	...	...	...	...	...	...	10.6	24.4	...	...	...	...	...	...	...
Average............		10.46	23.04	0.52	11.01	22.84	0.87	10.37	23.30	0.93	10.37	22.61	1.49	...	...	...
Maximum Spread...		0.4	4.63	0.43	2.31	2.84	2.56	0.40	2.00	0.73	0.59	2.59	0.39	...	...	...

NOTE.—See Table If or subscripts.

TABLE III.—RECAPITULATION OF AVERAGE RESULTS AND SPREAD OF RESULTS FOR MIXTURES NOS. 1 AND 2 ANALYZED BY FOUR PROPOSED METHODS.

Mixtures: No. 1—Oil Asphalt Cement, Limestone Dust Filler; No. 2—Oil Asphalt Cement, Portland Cement Filler.

NOTE.—The "spreads" of individual results, shown under the columns for the averages of the four methods, are the difference between the maximum and minimum result for each of the series indicated.

An average of the results on the two mixtures has been shown inasmuch as the mixtures were made to analyze alike as nearly as possible.

		Centrifuge Tube Method		Dulin Rotarex Method		Barber Asphalt Method		Thimble Extraction Method		Average of Four Methods		
Mixture........................		No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	Grand Average Nos. 1 and 2
Bitumen..........	Average..	10.33	10.46	10.95	11.01	10.24	10.37	10.35	10.37	....	....	....
	Spread...	0.81	0.40	2.83	2.31	0.30	0.40	0.74	0.59	....	....	....
Bitumen +200 Mesh..........	Average..	22.75	23.04	22.31	22.84	23.08	23.30	22.55	22.61	....	....	....
	Spread..	3.20	4.63	4.16	2.84	1.60	2.00	3.29	2.50	....	....	....
Correction.........	Average..	0.56	0.52	1.01	1.23	0.76	0.93	1.49	1.49	....	....	....
	Spread...	0.49	0.43	1.77	2.21	0.12	0.73	0.50	0.30	....	....	....
Corrected Average: Eliminating Laboratories Nos. 3 and 6.												
Bitumen..........	Average..	Values Unaffected —Same as Above		10.53	10.77	Values Unaffected —Same as Above		Values Unaffected —Same as Above		10.36	10.49	10.43
	Spread...			0.63	0.30					0.85	0.79	0.90
Bitumen +200 Mesh..........	Average..			22.47	22.77					22.72	22.63	22.68
	Spread...			1.61	2.03					3.79	4.63	4.63
Correction.........	**Average..**	....	....	....	....	....	....	....	....	0.93	0.96	0.96
	Spread...	....	....	....	....	....	....	....	....	1.44	1.38	1.48

gave the most consistent results when compared with its average result; which method was least affected by difference in type of fillers; which method gave results most consistent with the averages of all methods; and the size of the unavoidable error to be expected for this particular test, bearing in mind that the order of magnitude of unavoidable variation in the samples themselves was probably not far from the order of magnitude of variation in results.

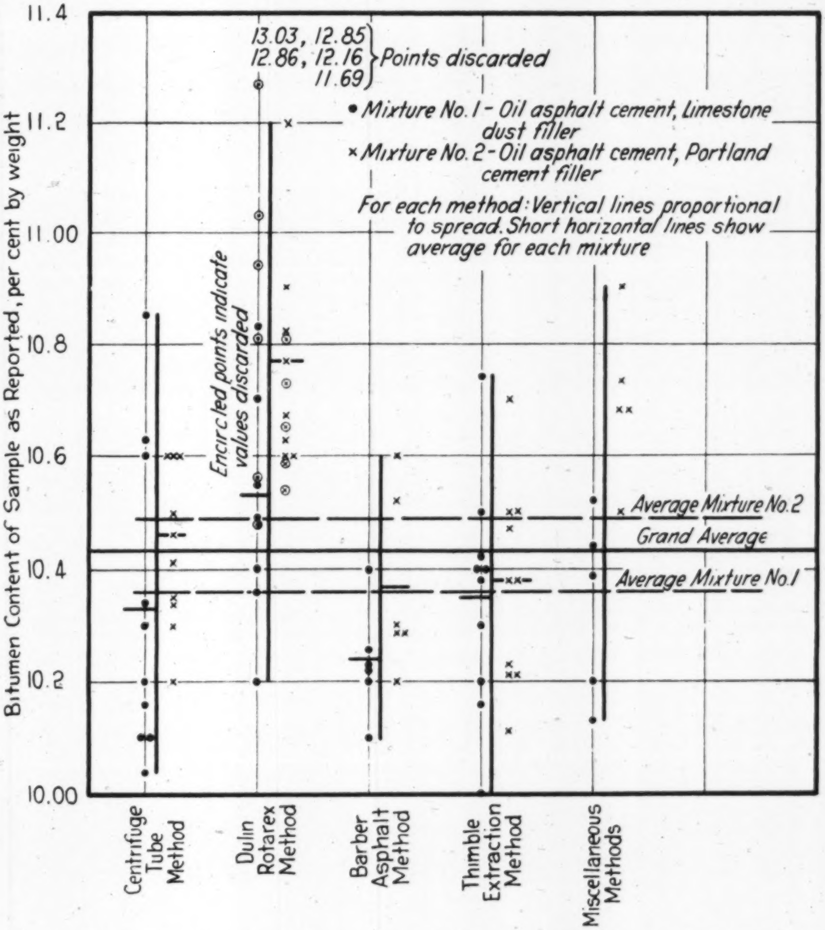

FIG. 1.—Determination of Bitumen in Two Mixtures of Bituminous Aggregates by Various Methods of Extraction.

Table III is a recapitulation of the average results and the spread of individual results for the four principal methods shown in Tables I and II. In the lower portion of Table III, the average results for the Dulin rotarex method have been recalculated, discarding results in which there was definite indication of error, and these corrected averages were combined with the averages for the other three methods shown in the first part of the table in calculating the average result for each sample by all methods and the grand average for both samples. Figure I summarizes graphically the results for bitumen determination shown in Tables I, II and III, and shows the significance of the comparisons made. While the determination of bitumen is of principal importance in the present investigation, accuracy of results in the dependent stages of the complete test is also of interest. Table IV compares directly the variation of results for the principal stages of the test on both a weight and percentage basis.

TABLE IV.—UNIFORMITY OF RESULTS OF PRINCIPAL STAGES OF THE TEST BY THE FOUR PROPOSED METHODS (USING CORRECTED AVERAGES).

Mixtures: No. 1—Oil Asphalt Cement, Limestone Dust Filler; No. 2—Oil Asphalt Cement, Portland Cement Filler.

		Centrifuge Tube Method		Dulin Rotarex Method		Barber Asphalt Method		Thimble Extraction Method		Average of Four Methods	
Mixture		No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
On a Bitumen Basis	Maximum Variation in Each Group, per cent	7.8	3.8	6.0	2.8	2.9	3.9	7.2	5.7	8.2	7.5
	Deviation of Average of Each Method from Grand Average:										
	Difference in points	−0.10	+0.03	+0.10	+0.34	−0.10	−0.08	−0.09	−0.06	−0.065	+0.065
	Difference, per cent of Grand Average	−9.6	+2.9	+9.6	+3.3	−18.2	−7.6	−7.6	−5.8	−6.2	+6.2
On a Bitumen +200 Mesh Basis	Maximum Variation in Each Group, per cent	14.1	21.0	7.2	8.9	6.9	8.6	14.6	11.5	16.7	20.4
	Deviation of Average of Each Method from Grand Average:										
	Difference in points	−0.07	+0.36	−0.21	+0.10	+0.42	+0.62	−0.13	−0.08	−0.045	+0.045
	Difference, per cent of Grand Average	−0.31	+1.59	−0.93	+0.44	+1.85	+2.73	−0.57	−0.35	−0.20	+0.20
On a Correction Basis	Maximum Variation in Each Group, per cent	88	83	....	....	16	79	34	26	155	141
	Deviation of Average of Each Method from Grand Average:										
	Difference in Points	−0.40	−0.44	....	....	−0.20	−0.03	+0.50	+0.53	−0.025	+0.025
	Difference, per cent of Grand Average	−41.7	−45.9	....	....	−20.8	−3.1	+52.1	+55.2	−2.6	+2.6
Summary	Maximum Variation in Each Group, per cent:										
	Bitumen	7.8	3.8	6.0	2.8	2.9	3.9	7.2	5.7	7.8	7.5
	Bitumen +200 Mesh	14.1	21.0	7.2	8.9	6.9	8.6	14.6	11.5	16.7	20.4
	Correction	88.0	83.0	....	....	16.0	79.0	34.0	26.0	155.0	141.0
	Deviation of Average of Each Method from Grand Average, Per Cent of Grand Average:										
	Bitumen	−9.6	+2.9	+9.6	+3.3	−18.2	−7.6	−7.6	−5.8	−6.2	+6.2
	Bitumen +200 Mesh	−0.31	+1.59	−0.93	0.44	+1.85	+2.73	−0.57	−0.35	−0.20	−0.20
	Correction	−41.7	+45.9	....	....	−20.8	−3.1	+52.1	+55.2	−2.6	+2.6

Discussion of Data:

1. Estimating the maximum error as one-half the total spread, and the probable error as one-half the maximum error (which estimate is high for a probable error) the expected errors, using any method and any type of filler, are as follows:

		POINTS IN RESULT	PERCENTAGE OF RESULT
For percentage bitumen	Probable error	±0.2	±2
	Maximum error	±0.4	±4
For percentage bitumen plus 200 mesh	Probable error	±2.0	±0.9
	Maximum error	±4.0	±1.7

2. Considering each method by itself, the centrifuge tube, Dulin rotarex and thimble extraction methods show relatively high probable errors for the limestone filler; and the thimble extraction method a relatively high error for the portland cement filler as well.

3. Dulin rotarex method shows definitely high values for bitumen.

4. "Bitumen + 200 mesh" is relatively very uniform for all methods with the Barber asphalt method showing a tendency to be high.

5. Thimble extraction method shows unusually high corrections.

6. Considering each method by itself, the Barber asphalt method shows the best agreement for both mixtures, with the expected probable and maximum errors approximately one-half of what they would be by using all systems.

7. Mixture No. 2 shows higher bitumen and bitumen plus 200 mesh than mixture No. 1.

8. The spread of results is about equal for mixtures Nos. 1 and 2.

9. No attempt was made to weigh the averages of individual methods in calculating the combined average, as there appeared to be no basis for doing this which would add to the value of the results.

10. A corrected average was used for the Dulin rotarex method, obtained by omitting the results of laboratory No. 3 which showed obviously high and erratic values for bitumen; and laboratory No. 6 which showed obviously low and erratic values for bitumen plus 200 mesh. This put the average for bitumen much closer to the average of other systems, affected only slightly the average for bitumen plus 200 mesh and materially decreased the spread of results for both quantities.

11. The miscellaneous methods were not susceptible of statistical study, but the individual results compare favorably with the general averages in all cases.

12. No distinction was made between results on the basis of size of sample and type of solvent used, as the data were not sufficiently comprehensive to allow general comparison in these respects. Inspection of such data as were obtained, however, does not indicate that either of these factors would have altered the averages.

Respectfully submitted on behalf of the subcommittee,

J. S. MILLER, JR.,
Chairman.

APPENDIX

PROPOSED METHODS FOR TESTING SHEET ASPHALT PAVING MIXTURES

PREPARATION OF SAMPLE

1. *Preparation of Sample.*—The sheet asphalt mixture shall be softened by heating in an oven at 225° F. just sufficiently to be able to disintegrate it with a putty knife or spatula. In order to avoid any change in the sample which might be due to the reheating of the same, it is advisable to weigh out a sufficient number of 10-g. and 25-g. portions after the initial heating.

NOTE.—The time required in Method C for heating is about 10 minutes and only 10-g. portions are required.

METHODS OF TESTING

Method A. Centrifuge Tube

2. *Apparatus.*—The apparatus to be used in this test shall be any suitable type of centrifugal machine capable of being rotated rapidly (1800 r.p.m.) surmounted by a head carrying an equal number of metal tube shields, slightly larger than the glass tubes used, and provided with rubber cushions, the whole being encased in a metal shield. In place of glass tubes aluminum or bronze tubes may be used.

3. *Procedure.*—The required quantity (10 or 25 g.) of the disintegrated sample selected at random throughout the sample shall be accurately weighed on a tared watch glass or weighing scoop. After weighing, the sample shall be transferred to a numbered and weighed tube. The tube shall be filled with a definite quantity of carbon disulfide approximately three-fourths full and then inserted in the metal tube shield of the centrifuge machine. The tubes shall be so placed in the centrifuge machine as to have equal weights opposite each other around the head of the centrifuge. After allowing the material in the tube to digest for about 15 minutes, the centrifuge machine shall be started, slowly at first, gradually bringing it up to full speed and whirling from 5 to 10 minutes. The machine shall then be stopped, the tube removed and the solvent and dissolved bitumen decanted into a numbered flask. The tube shall again be filled with carbon disulfide, mixing the solid matter at the bottom of the tube with the solvent by stirring, the material allowed to digest for 15 minutes, whirled from 5 to 10 minutes, the solvent decanted and the bitumen dissolved as before. This operation shall be repeated from three to five times or until the solvent in the tube, after whirling from 5 to 10 minutes, is clear and colorless.

The tube shall now be removed from the machine and the solvent allowed to evaporate from the aggregate at room temperature and the material then dried in an oven at 212° F. to constant weight, cooled in a desiccator and weighed (see Explanatory Note).

The solvent and dissolved bitumen in the flask shall be rinsed into a weighed porcelain or silica evaporating dish and the solvent burned off under a hood.

The residue shall then be ignited over a gas flame or in a muffle until it is entirely free from carbon, allowed to cool in a desiccator and the ash weighed and its weight added to the weight of the mineral matter in the tube. Should there be a considerable amount of ash recovered in this manner, and if it is found that the mineral matter is calcium or other carbonate, it shall be recarbonated by repeated treatment with ammonium carbonate solution and finally ignited at a dull red heat. Ordinarily the mineral matter in the solution is found to be so small that the difference caused by ignition may be neglected.

Method B. Dulin Rotarex

2. *Apparatus.*—The apparatus to be used in this test shall be a Dulin rotarex of at least 50-g. capacity. It shall be mounted on a strong, substantial bench in order to prevent undue vibration.

3. *Procedure.*—The filter ring shall be dried for 30 minutes in an oven at 212° F., allowed to cool in a desiccator and then weighed.

The required quantity (10 or 25 g.) of the disintegrated sample shall be accurately weighed on a tared watch glass or weighing scoop. The sample shall then be placed in the bowl of the rotarex machine, care being taken to evenly distribute the mixture around the periphery of the bowl to prevent vibration during the extraction. The filter ring and bowl plate shall then be placed on the bowl and fastened down fairly tight. The bowl shall then be placed in position in the rotarex machine and from 40 to 50 cc. of carbon disulfide poured into the bowl through the funnel opening. After allowing the material to digest for about 15 minutes, the motor shall be started, slowly at first, and then the speed increased sufficiently to cause the dissolved bitumen to flow from the spout in a thin stream. The dissolved bitumen or filtrate shall be collected in a beaker or other receptacle. When the first charge has drained, the motor shall be stopped and a fresh charge of carbon disulfide added and again allowed to digest for 15 minutes and the machine started as before. This operation shall be repeated from three to five times or until the solvent runs clear from the spout showing all bitumen has been dissolved from the sample, this usually requiring three to four washings.

When the last addition of solvent has drained off, the bowl shall be removed and placed with the bowl plate and filter ring on a sheet of glazed manila paper and allowed to dry at room temperature. The aggregate shall then be brushed from the bowl onto the paper together with any aggregate adhering to the bowl plate and filter ring. The aggregate shall then be transferred to a tared watch glass or pan and together with the filter ring dried in an oven at 212° F., cooled in a desiccator and weighed (see Explanatory Note).

In making the correction for the mineral matter suspended in the filtrate, add sufficient carbon disulfide to bring the same to a definite volume and a multiple of 100 cc. The whole filtrate shall then be thoroughly shaken so that the mineral matter is uniformly dispersed throughout the filtrate and an aliquot part of 100 cc. then taken and transferred into a weighed porcelain or silica evaporating dish and the solvent burned off under a hood. The residue shall then be ignited over a gas flame or in a muffle until it is entirely free from carbon, cooled and weighed and the total ash correction determined as follows:

$$\text{Total ash} = \frac{\begin{array}{c}\text{Total filtrate in}\\ \text{cubic centimeters}\end{array} \times \begin{array}{c}\text{Ash in grams recovered in}\\ \text{aliquot part}\end{array}}{\text{Aliquot part in cubic centimeters}}$$

Should there be a considerable amount of ash recovered in this manner, and if it is found that the mineral matter is calcium or other carbonate it shall be recarbonated by repeated treatment with ammonium carbonate solution and finally ignited at a dull red heat.

Method C. Barber Asphalt Method

2. *Apparatus* (*a*).—The extraction apparatus shall consist of a 400-cc. tall-form glass beaker without a lip, a spring brass ring for supporting the filter paper in the beaker and a glass condenser of special design.

(*b*) The extractor shall be heated by means of a hot-air bath, the source of heat being either an ordinary carbon filament electric bulb or a 1000-ohm Ward Leonard Vitrohm resistor unit, or any other satisfactory heating unit.

3. *Procedure.*—A No. 2 Whatman filter paper, 11 cm. in diameter shall be folded twice (not fluted) in the usual manner, dried for 30 minutes in an oven maintained at a temperature of 212 to 225° F. allowed to cool in a desiccator and then weighed as quickly as possible.

Ten grams of the disintegrated mixture selected at random throughout the sample shall be accurately weighed in a tared weighing scoop and then carefully transferred into the tared filter paper. The filter paper shall then be supported in the glass beaker by means of the spring brass ring in such a manner that its entire upper edge will be in contact with the bottom of the condenser when the apparatus is assembled. The sample shall then be covered with carbon disulfide taking care not to overflow the filter paper. The remainder of the 75 cc. of solvent required for the extraction shall be poured directly into the beaker. The extractor shall then be placed over the air bath, the condenser placed in position and cold water circulated through it. Just sufficient heat shall be applied to vaporize the solvent at such a rate that the condensate does not overflow the filter paper.

When the solvent drips through colorless the extractor shall be removed from the air bath and the filter paper and sample washed with a fine jet of carbon disulfide from the wash bottle, to wash out any bitumen that may be retained at the top of the filter, and allowed to drain into the extractor. If the washings show any color, the extraction shall be resumed until the solvent comes through colorless. The filter paper and residue shall then be removed from the extractor and placed on a holder, and the solvent allowed to evaporate completely at room temperature. It shall then be dried in an oven at 212° F. for 30 minutes, cooled in a desiccator and weighed as quickly as possible.

The filtrate in the extractor shall be rinsed into a weighed silica evaporating dish and the solvent burned off under a hood. The bitumen shall then be ignited over a gas flame or in a muffle furnace until entirely free from carbon, allowed to cool in a desiccator and the ash weighed, and its weight added to the weight of the mineral matter in the filter paper. The mineral matter going through the filter paper is usually so small in amount that the difference caused by ignition when carbonates are present will be negligible.

Method D. Thimble Extraction

2. *Apparatus.*—The extraction apparatus shall conform to that described in Section 8 of the Standard Methods of Testing Rubber Products (A.S.T.M. Designation: D 15) of the American Society for Testing Materials.[1]

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

3. *Procedure.*—A Whatman filter thimble, fat free, 60 mm. in length by 26 mm. in outside diameter shall be dried for 30 minutes in an oven at 212° F. and allowed to cool in a desiccator and then weighed in a suitable weighing bottle.

The required quantity (10 or 25 g.) of the disintegrated sample shall be accurately weighed on a tared watch glass or weighing scoop. After weighing carefully, the sample shall be transferred to the tared thimble and, when assembled, 40 to 50 cc. of carbon disulfide poured over the sample. A disk of wool felt or plug of absorbent cotton shall be placed over the sample in the top of the thimble in order to distribute the solvent uniformily and prevent splashing. The thimble containing the sample shall be suspended under the condenser by a fine wire bail. Cold water shall be circulated through the condenser. The flask shall then be cautiously heated by means of a steam-bath or electric heater. Just sufficient heat shall be applied to vaporize the solvent without actual boiling or at least at such a rate as to prevent condensate overflowing the thimble.

The extraction shall be continued until the carbon disulfide runs colorless when the thimble shall be removed and washed with a fine jet of carbon disulfide from a wash bottle to wash out any bitumen that may be retained at the top thereof and to break up any channels that may have formed by the carbon disulfide passing through. If the washings show any color, the thimble shall be put back and the extraction continued until the solvent comes through colorless.

The thimble shall then be removed from the extractor and the solvent allowed to evaporate completely from the aggregate at room temperature in order to prevent ignition of the absorbed CS_2. The material shall then be dried in an oven at 212 F. to constant weight, cooled in a desiccator and weighed.

The solution in the flask shall be rinsed into a weighed porcelain or silica evaporating dish and the solvent burned off under a hood. The residue shall then be ignited over a gas flame or in a muffle until it is entirely free from carbon and the ash weighed and the weight of the ash added to that of the mineral matter in the thimble. This is to correct for the fine mineral matter which may be carried through the thimble. Should there be a considerable amount of ash recovered in this way, and if it is found that the mineral matter is calcium or other carbonate it shall be recarbonated by repeated treatment with ammonium carbonate solution and finally ignited at a dull red heat. Ordinarily the mineral matter going through the thimble will be so small in amount that the difference caused by ignition may be neglected.

CALCULATION

10. *Calculation.*—The difference between the original weight of the sample used and the combined weight of the ash and mineral matter represents the weight of bitumen present. This shall then be calculated to percentage.

EXPLANATORY NOTE

NOTE: *Sieving of Mineral Aggregate.*—After having recorded the weight of the dry mineral aggregate from the extracted sample, the mineral aggregate shall be sifted through the Nos. 200, 100, 80, 50, 40, 30, 20 and 10 sieves and the percentage passing each sieve reported on the basis of the total sample used in the extraction.

REPORT OF COMMITTEE D-5
ON
COAL AND COKE

Committee D-5 on Coal and Coke held one meeting during the past year at Cleveland, Ohio, on March 7, and another during the annual meeting of the Society. The committee is recommending a method of sampling coke for analysis for publication as a tentative standard and the inclusion of a ball-mill method for the laboratory sampling of coal as an alternate procedure in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30). The present Tentative Definition of the Term Coke (D 121 – 30 T) is being continued as tentative pending consideration by Committee E-8 on Nomenclature and Definitions of a revised definition which has been proposed by a subcommittee of Committee E-8.

A new subcommittee, designated as Subcommittee XI on Coal Friability, under the chairmanship of R. E. Gilmore, has been formed to investigate present methods used in testing friability of coal with a view to standardizing this method of test. The test is a measure of the degradation in size of coal on handling and is of considerable commercial importance. Different methods are now used in testing friability, and experimental work from several laboratories has been published. Obviously, a standardization of the test is desirable.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Methods of Testing (A. C. Fieldner, chairman). —In cooperation with Subcommittee VI on Agglutinating Value, progress has been made in the study of the various factors that affect the agglutinating value test for coal. The investigation is being conducted at the Pittsburgh Experiment Station of the U. S. Bureau of Mines. A proposed method of test has been developed and is being used on a number of different coals. Closely-sized Ottawa sand is mixed in a series of definite proportions with the finely ground coal and the mixture carbonized for 20 minutes at a temperature of 950° C. in the same type of electric furnace as used for determining the volatile matter in coal. The carbonized buttons are then tested for crushing strength. The agglutinating values obtained at various ratios of coal and sand are expressed in kilograms pressure required to crush the carbonized buttons.

This subcommittee recommended, at the meeting of Committee D-5 held at Cleveland, Ohio, a ball-mill method as an alternate procedure for the laboratory sampling of coal. This method of preparing coal samples for analysis is that used at the Pittsburgh Station of the U. S. Bureau of Mines and is an accurate method of preparing coal samples for analysis, suitable for use in laboratories equipped with ball-mills. The method was approved by Committee D-5 for publication as a tentative revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30) to be subsequently added to the standard methods as an alternate method with the present standard method.

Subcommittee II on Nomenclature and Definitions (H. C. Porter, chairman).—This subcommittee is cooperating with a subcommittee of Committee E-8 appointed to harmonize various definitions of the term "coke" that have been submitted by different committees of the Society. This subcommittee of Committee E-8 has formulated the following definition for coke, which definition is now under consideration by Committee E-8:

> *Coke.*—The infusible, cellular, coherent solid material obtained as a residue by the destructive distillation of certain organic materials, whereby the physical structure results from the decomposition and hardening of a fused or liquid mass.
>
> NOTE.—In the present state of the art, in addition to coal, petroleum or petroleum residues and pitch are sources of coke. Specific varieties of coke, other than those from coal, are usually given a distinguishing prefix to indicate their source, as for example, "petroleum coke" and "pitch coke." A distinguishing prefix may also be given to indicate the process by which coke is manufactured from coal, as for example, "beehive coke," "by-product coke," and "gas-house coke."

The subcommittee is also cooperating with a subcommittee of Committee E-8 to formulate definitions of the terms "net calorific value" and "gross calorific value." Progress has been made but no specific recommendations can be made at the present time.

Subcommittee IX on Coke Sampling (O. O. Malleis, chairman).—This subcommittee has been active during the past year and recommended at the Cleveland meeting of Committee D-5 a method of sampling coke for analysis. The method is similar in many respects to the present Standard Method of Sampling Coal (D 21 – 16). Smaller gross samples are permitted for coke than for coal, as coke is generally more uniform in composition than is coal. The collection of gross samples as given in the method conforms to ideas of coke chemists who have had long experience in sampling coke. The method appended hereto[1] has been approved by Committee D-5 for presentation to the Society for publication as tentative.

Progress is being made by the subcommittees on sampling tolerances, pulverizing characteristics of coal, and foundry coke specifications, but the work of these subcommittees has not progressed sufficiently to warrant the submission of reports or recommendations.

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[1] See p. 789.—ED.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Tentative Method of Sampling Coke for Analysis.—It is recommended that this method of sampling, appended hereto,[1] be accepted for publication as tentative.

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 30).[2]—The ball-mill method of preparing samples of coal for analysis, appended hereto,[3] is intended as an optional method of sampling in addition to the methods now standard. It is recommended that this ball-mill method be accepted for publication as a tentative revision in the form of a separate tentative standard to be added when adopted as standard to the present methods.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Method of Sampling Coke for Analysis	35	0	7
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 30)	36	0	6

This report has been submitted to letter ballot of the committee, which consists of 42 members; 40 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

W. A. SELVIG,
Secretary.

H. C. PORTER,
Vice-Chairman.

EDITORIAL NOTE

The proposed Tentative Method of Sampling Coke for Analysis was accepted for publication as tentative and appears on page 789.

The proposed revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke, in the form of an optional method of sampling, entitled Tentative Method of Sampling Coal by Ball-Mill Method, was accepted for publication as tentative and appears on page 794.

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[1] See p. 789.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 689.

[3] See p. 794.—ED.

REPORT OF SECTIONAL COMMITTEE
ON
CLASSIFICATION OF COALS

During the past year the Sectional Committee on Classification of Coals, functioning under the procedure of the American Standards Association, has continued to collect and correlate facts and data on the composition, properties, and uses of North American coals. Thirteen papers giving results of some of this work were presented and discussed at the third Symposium on the Classification of Coal held at the February, 1932, meeting of the American Institute of Mining and Metallurgical Engineers. These papers and the discussions will be published in the 1932 *Transactions* of the Coal Division of the Institute. Aside from the immediate subject of coal classification these papers contain a wealth of valuable information on coal technology. The foreign point of view on classification has been presented by English and German technologists in several papers(**1, 2, 3, 4**)[1] read and discussed at the Third International Conference on Bituminous Coal held at Pittsburgh, November, 1931. A review of the work of the sectional committee was presented by Mr. H. J. Rose(**5**), chairman of the Technical Committee on Scientific Classification of Coal. The presentation of these papers and the ensuing discussion at these two conferences have aided greatly in clarifying the complex problem of coal classification.

Intimate contact with the Associate Committee on Coal Classification of the National Research Council of Canada has been continued with mutual profit. Representatives of the Canadian committee have attended all meetings of the sectional committee. The chairman of the American committee attended the Montreal meeting of the Canadian committee on April 4, 1932. The Mines Department and the National Research Council of Canada and the Research Council of Alberta have been particularly active in making surveys of the properties of Nova Scotia and Alberta coals, the latter being important because of the range in rank from lignite to bituminous coal. An informative review of the composition and classification of Canadian coal was presented by Stansfield(**6**) at the Fuel and Coal Symposium held in October and November, 1931, at McGill University, Montreal.

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[1] The boldface numbers in parentheses refer to the reports and papers given in the list of references appended to this report, see p. 444.

The sectional and technical committees held two group meetings during the past year, one in Pittsburgh, Pa., on November 19, 1931, and the other in New York City on February 16, 1932. At the February meeting all the officers of the sectional and technical committees were re-elected for two years, and a vacancy in the Executive Committee was filled by the election of Mr. W. H. Fulweiler. The work of the three technical committees during the past year is described below.

ACTIVITIES OF TECHNICAL COMMITTEES

Technical Committee on Marketing Practice (F. R. Wadleigh, chairman).—This committee did not hold any separate meetings but met with the other committees and advised on marketing practice.

Technical Committee on Use Classification (W. H. Fulweiler, chairman).—This committee in cooperation with the Fuel Committee of the National Association of Purchasing Agents sent out questionnaires on grades and classes of coal used in steam generating plants, and on factors affecting the use of coal with different types of stokers and furnaces. A progress report on the results of this questionnaire was submitted at the November meeting of the committee. Another subcommittee, headed by Mr. A. H. Willett of the National Coal Association, circularized all the cities in the United States, 93 in number, having a population in excess of 100,000, with reference to provisions in smoke abatement ordinances relating to differences in kind or quality of fuel. The replies received, together with a recently published digest(7) of smoke ordinances, have furnished data needed by the committee for establishing a division line between the so-called "smokeless" or low-volatile coal and medium-volatile coal. The collection of data on the requirements of coal for various uses was continued and reports were completed on coals used in the portland cement(8), ceramic(9) and non-ferrous metallurgical(10) industries.

Technical Committee on Scientific Classification (H. J. Rose, chairman).—This technical committee has been very active through the work of its various subcommittees.

Subcommittee I on Nature, Location and Mode of Occurrence was instrumental in stimulating much needed work by various organizations in filling in gaps where physical and chemical data were lacking. The U. S. Bureau of Mines in cooperation with the Anthracite Institute is making a survey of the chemical and physical properties of Pennsylvania anthracite. A similar survey of all the mines in the state of Washington was completed by the Bureau and published(11, 12). This survey, which included all ranks of coal from lignite to anthracite, was of particular value in showing the relative merits of various chemical and physical criteria, such as moisture, B.t.u., fixed carbon, friability and slacking properties for the classification of coal(13). Similar data are being obtained in surveys of Canadian coal fields by the Mines Department and Research Council of Canada. The U. S. Geological Survey has completed a survey of Arkansas coals(14) which fills in one of the existing gaps in the twilight zone between anthracite and bituminous coal. Considerable data have been published in recent years on the friability of coals from Canada(15, 16), Washington(11, 12), Illinois(17, 18), and West Virginia(19). Similar work is in progress on Pennsylvania anthracite and bituminous coal.

Subcommittee II on Methods of Analysis, Origin and Composition of Coal has continued to review the methods used in coal analysis and their application to the classification of coal. The need for standardization of methods for determining the friability of coal has been recognized by Committee D-5 on Coal and Coke of the American Society for Testing Materials by the appointment of a subcommittee for standardizing such a method under the chairmanship of Mr. R. E. Gilmore of the Department of Mines, Canada. Friability tests thus far reported by various workers indicate a rough relationship between friability and rank of coal. Low-volatile bituminous coals usually were found to be much more friable than either medium-volatile coals or anthracites.

The U. S. Bureau of Mines' study(11) of the slacking properties of coals from Washington and other states has been completed on a series of coals of various ranks ranging from lignite to anthracite. It appears from these results that the first cycle slacking index may serve as a means of differentiating between sub-bituminous and bituminous coals. Almost all of the United States coals thus far tested which showed more than 12,000 B.t.u. on "as mined, ash-free" basis were found to have a slacking index of less than 5 (non-slacking class). At approximately this point in the B.t.u. scale of rank, the slacking index began to rise above 5. Similar studies on Canadian coals are being conducted by the Associate Committee on Coal Classification, and in addition the alkali-soluble ulmins(20) in coal are being studied with particular reference to subdivision into classes of the lower ranks of coal.

As pointed out by Rose(5), most systems for the scientific classification of coal are based on analyses calculated to the dry (105° C.) basis, and this basis admittedly has advantages when comparing coals of similar or high rank. However, the committee has come to the conclusion that when devising a classification to include coals of all ranks, a basis including normal moisture content of the coal as it occurs in the bed is not only desirable but necessary. This is a conclusion which has long been held by geologists and others who have had an opportunity to become familiar with the properties of low-rank coals.

If then, it is decided to classify coals on a moist basis, it will be necessary to have a method for determining the true inherent moisture in such samples which may have additional adventitious moisture or which may have lost some of the true moisture by evaporation. The Associate Committee of Canada has given special attention to this problem, and Stansfield and Gilbart(21) have developed a method involving the exposure of samples to atmospheres of increasing humidities up to nearly 100 per cent. By plotting the moisture retained in the coal against the relative humidity and extrapolating the curves to 100 per cent humidity, the true moisture is read off at the point where the curve intersects the 100 per cent humidity coordinate. While this method requires further study, it promises to afford a means of determining the true moisture where the ordinary mine-sample is suspected of not showing the true moisture. The whole subject of the condition of water in coals of various ranks has been reviewed by Gauger(22) and further studies along this line are being conducted by him at the Mineral Industries Experiment Station of Pennsylvania State College.

Further studies have been made of the use of formulas for computing the mineral matter in coal from the ash(23). The Parr formula for determining "unit coal" gives slightly better results in correcting for both ash and sulfur than any other formula tested by the subcommittee. However, this formula, as well as others, is based on averages and does not apply closely to some individual coals, especially those which are high in both pyrite and carbonates. In such cases it seems best to reject the bulk of the impurities by crushing the coal and then floating it on a heavy-gravity liquid before making the analysis. In testing the accuracy of various formulas against the Stansfield and Sutherland "fractionation method"(24) data have been obtained on certain approximate formulas, such as, mineral matter = 1.1 ash, and mineral matter = $1\frac{1}{8}$ ash. These formulas are much simpler to calculate, and the results are surprisingly close to those given by the Parr formula on low-sulfur coals.

Comprehensive studies of the constitution of a series of American coals in relation to their carbonizing properties have been conducted throughout the entire year by the U. S. Bureau of Mines in cooperation with the American Gas Association, and a number of reports have been published(25, 26, 27, 28). This investigation includes a systematic examination of the chemical and physical properties of the coal, the microstructure of a columnar section of the coal bed, and the yields and properties of the coke and by-products resulting from carbonization at various temperatures ranging from 500 to 1100° C. The Mines Branch of the Department of Mines of Canada also has studied the carbonizing properties of a number of coals and has published(29) a system of classifying coals for use in the by-product coking industry. In this system the percentage of volatile matter is plotted against the "specific volatile index." The "specific volatile index" is computed by the following formula:

$$\text{Specific volatile index} = \frac{\text{determined B.t.u. of coal} - (\text{per cent fixed carbon} \times 14{,}500)}{\text{per cent volatile matter}}$$

By this method of plotting, coals of various ranks fall in an approximate straight line with lignites on one end and anthracite on the other. Further study of this scheme may show that it has certain advantages for the scientific as well as the use classification of coal.

Subcommittee IV on Tentative Classification of Coals has continued the plotting of some 10,000 analyses of American coals on the multibasic coal charts. These charts consist of graphs for the various districts and beds, in which the percentage of fixed carbon is plotted against the B.t.u. of the ash-free, as-mined coal. Other important properties such as slacking index, friability, coking index, etc., are indicated on the graphs in order to furnish a picture of how the various coals may best be grouped into classes. A progress report(30) and a general review of the present status of scientific classification of American coals was presented at the symposium held in New York in February.

In conclusion, it may be said that the fact-finding period which of necessity preceded the actual work of classification is now drawing to a close. Further laboratory work is of course necessary, but the data now on hand are sufficient to proceed with the selection of the criteria for the various classes according to the rank of the coal. It is expected that a tentative classification by rank will be submitted for consideration by the Technical Committee on Scientific Classification at the fall meeting, and by next year it is hoped that the committee will report the approval of several phases of the work on coal classification.

Respectfully submitted on behalf of the sectional committee,

A. C. FIELDNER,
Chairman.

C. B. HUNTRESS,
Secretary.

APPENDIX

References

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REPORT OF COMMITTEE D-7
ON
TIMBER

Committee D-7 on Timber through its various subcommittees reports the following activities:

Subcommittee I on Specifications for Timber (C. E. Paul, chairman).—This subcommittee has considered the Tentative Specifications for Timber Piles (D 25 – 30 T). It has devoted considerable time to the discussion of the original specifications for piles with specific reference to highway work; also criticisms with reference to size of knots and thickness of sapwood permitted, particularly in relation to the species of timber. It is anticipated that after another year's work final recommendation may be made. It is accordingly recommended that these specifications be continued as tentative.

A special section of this subcommittee, consisting of L. J. Markwardt, M. O. Withey and A. T. Upson, appointed to consider revisions of the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (D 245 – 30) has made considerable progress during the year. Tentative revisions of the sections relating to rough sizes are being prepared for presentation to the main committee. These changes are aimed to clarify the intent of the specifications that rough green timbers should be full sawn, tolerance being provided only for unavoidable deviations in sawing. A few changes are also being considered in the dressed dimensions specified to make them conform to American Lumber Standard sizes. A second phase of the work dealing with clarification of the method of measuring checks shows less progress because of the difficulty of setting up new methods of measurement without sacrificing desired simplicity, and because of the lack of fundamental information on the effect of checks on shearing strength, particularly for beams loaded near the supports. The results of a study of the shearing strength of checked beams now under way at the U. S. Forest Products Laboratory have a direct bearing on revision of the specifications relating to checks, and final recommendation will no doubt await the results of this research work.

Subcommittee VI on Timber Preservatives (S. R. Church, chairman).—This subcommittee presents a report, appended hereto, dealing with the tentative revision of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 30), recommending the withdrawal of portions of the tentative revision of this standard and in place thereof submits for publication as tentative new creosote correction tables to be issued as a separate tentative standard.

Proposed Tentative Standard.—The committee recommends for publication as tentative, the proposed Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars), as appended hereto.[1] These proposed tables are to replace the tables published since 1929[2] as a tentative revision of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 30).

Tentative Standards Continued as Tentative.—Committee D-7 has given careful consideration through its several subcommittees to the existing tentative standards under its jurisdiction and recommends that the following be continued as tentative:

Tentative Specifications for Timber Piles (D 25 – 30 T);

Tentative Method for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 – 30 T);

Tentative Definitions of Terms Relating to Timber Preservatives (D 324 – 30 T).

The committee also recommends that the tentative revision of the Standard Method of Test for Distillation of Creosote Oil (D 246 – 30) be continued as tentative.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The recommendation appearing in this report has been submitted to letter ballot of the committee with the following results:

Item	Affirmative	Negative	Not Voting
PROPOSED TENTATIVE STANDARD Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars)............	18	0	7

This report has been submitted to letter ballot of the committee, which consists of 25 members; 19 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

The proposed Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) were accepted for publication as tentative and appear on page 797.

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[1] See p. 797.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, pp. 409, 410 (1929).

REPORT OF SUBCOMMITTEE VI ON TIMBER PRESERVATIVES

In the report of this subcommittee in 1931,[1] reference was made to the tables being prepared by the U. S. Bureau of Standards to supplement the creosote tables heretofore prepared and which now appear as a tentative revision of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 30).[2] Reference was also made to the results of the density test made on six samples of coke-oven tar.[3]

By making a number of determinations on the density of mixtures of creosote and coke-oven tar (commercially known as creosote coal-tar solutions) it was found that the thermal expansion of these solutions was almost identical with that of Group II of the present creosote tables. After discussion with representatives of the interested bodies, it was decided to accept the recommendation of the Bureau of Standards that the Group II creosote values be used for creosote coal-tar solutions containing not more than 50 per cent of coal tar. Tables were prepared giving in parallel columns the volume temperature corrections and the specific gravity temperature corrections for creosote, creosote coal-tar solution, and coal tar.

These tables have already been reported to the American Wood-Preservers' Association and have been sent out to letter ballot as tentative standards by that association.

It is now recommended that the proposed Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar, as appended hereto,[4] be accepted for publication as a separate tentative standard to replace the tables which were included as part of the tentative revision[2] of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 30).

A description of the method used by the Bureau of Standards in determining the density and thermal-expansion of creosote and tars used in preparing the correction tables, appears in *Technologic Paper No. 9,* "Density and Thermal Expansion of Linseed Oil and Turpentine."

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 31, Part I, p. 504 (1931).

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 31, Part I, p. 1065 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 931.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 820 (1930).

[4] See p. 797.—Ed.

In the 1931 report it was stated that a careful study would be made of the Standard Method of Test for Distillation of Creosote Oil (D 246 - 30), with the corresponding procedure appearing in the standards of the American Wood-Preservers' Association and the American Railway Engineering Association. This work is still being carried on under the auspices of a subcommittee of the A.W.P.A. Committee on Preservatives. It is believed that the proposed unification and the accompanying revision of the method will be ready for submission in time to appear in the 1933 Book of A.S.T.M. Standards. The subcommittee accordingly recommends that the tentative revision of these methods be continued as tentative.

The subcommittee recommends that the following tentative standards under its jurisdiction be continued as tentative:

Tentative Method for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 - 30 T);

Tentative Definitions of Terms Relating to Timber Preservatives (D 324 - 30 T).

Respectfully submitted on behalf of the subcommittee,

S. R. CHURCH,
Chairman.

REPORT OF COMMITTEE D-8

ON

BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

As an appendix to its 1931 annual report, Committee D-8 published a report from its Subcommittee on Refined Ductility Tests for Roofing Materials.[1] This report gave results of cooperative tests upon eight different samples of asphalt tested at 115 and 140° F., the purpose of the investigation being to devise a method of determining ductility of roofing asphalts that would differentiate bituminous materials of low ductility at 77° F. more accurately than the test in common use. These data have since been carefully reviewed and while it appears that the methods employed by the subcommittee do differentiate or magnify ductility differences which are not apparent under normal conditions of test, no indication has been secured that such differences have any significance relative to desirable or undesirable properties of the roofing asphalts examined. The committee therefore feels that it is not advisable to propose for adoption the tests developed by its subcommittee, as their use might lead to the preparation of confusing and inappropriate specifications.

A very valuable report of investigations conducted by the Subcommittee on Accelerated Weathering Tests was also published as an appendix to the 1931 committee report. During the past year this subcommittee has actively continued its work and the additional information obtained is considered of sufficient interest to warrant publication as an appendix to this report.

As no constructive criticisms have been received since its publication as a tentative method, Committee D-8 believes that the Tentative Method of Analysis of Roofing Felt for Fiber Composition (D 272 – 29 T)[2] should be advanced to standard. The letter ballot of the committee upon the approval of this method as standard resulted as follows: 38 members returned their ballots, of whom 31 have voted affirmatively, 2 negatively and 5 marked their ballots not voting.

However, in view of the desire of the Society to effect economy in publication this year, it would seem better to defer the publication of this method as standard until 1933, when the next edition of the Book of Standards will be issued.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 508 (1931).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 724 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 584.

The election of officers resulted in the selection of J. M. Weiss, chairman, C. N. Forrest, vice-chairman, and Prévost Hubbard, secretary, for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 44 members; 38 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. N. Forrest,
Acting Chairman.

Prévost Hubbard,
Secretary.

REPORT OF SUBCOMMITTEE VIII ON ACCELERATED WEATHERING TESTS

In the first series of cooperative accelerated weathering tests made by Subcommittee VIII no conditions of voltage, amperage and temperature were specified. The results of these tests were printed in the 1931 report of the subcommittee.[1]

In the present series of cooperative tests the lamp voltage and amperage were specified as 148 to 150 volts across the arc and the arc amperage as 10 to 13 amperes. The temperature of the panels during the light and cold cycles were specified at 140° F. and − 10° F., respectively. The duration of the test was specified to be 15 cycles.

Two kinds of asphalts were used in these tests. Ten members of the subcommittee submitted reports on these cooperative tests. A summary of their results is given in Table I.

Examination of Table I shows that the specified conditions of voltage, amperage and temperature were not maintained. These differences of conditions account for the variations in the results obtained by the various operators as shown by the photographs of asphalt A, Fig. 1 and asphalt B, Fig. 2.

The photographs show that in all cases the accelerated weathering test produced marked differences in the behavior of asphalt A and asphalt B and no difficulty is experienced in distinguishing the two types of asphalts.

There are similarities between panels (*a*), (*b*), (*c*), (*d*), (*h*) and (*i*) of asphalt A, Fig. 1. In the case of asphalt B, Fig. 2, panels (*a*), (*b*), (*c*), (*d*), (*h*) and (*i*) show similar behavior. Gratifying as these results may be there are, however, differences of degree rather than of kind and these must be eliminated before the accelerated test cycle can be considered standard.

The main problem of the standardization of accelerated weathering is the problem of standardizing the carbon arc, which is the principal feature of the test. The nature and intensity of the light radiated by the carbon arc lamp is dependent upon the nature of the carbon electrodes, the arc voltage, amperage and the length of the arc.

For the first step toward uniformity of lamps, the following control instruments should be recommended:

1. Two kilowatt-hour meters. The one meter should be connected with the power line so that the total input of electric energy can be measured. The other meter should be inserted across the arc to measure the electric energy in kilowatt-hours consumed by the

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 511 (1931).

carbon electrodes. This second meter will determine the constancy of the lamp.

2. A voltmeter and a double throw switch. The purpose of this meter is to determine the actual line and arc voltage. By turning the switch to one side the meter will read the line voltage, and when turned to the other side it will read the arc voltage. The arc voltage indicates whether or not the arc is functioning properly.

TABLE I.—RESULTS OF COOPERATIVE TESTS ON ACCELERATED WEATHERING TESTS.

	Current Consumption, kilowatt-hours	Line Voltage, volts	Arc Voltage, volts	Arc Amperage, amperes	Temperature of Panels During Light Cycle, deg. Fahr.	Detection of Differences in Behavior of Panels, cycles required	Final Breakdown of Panels	Refrigeration, deg. Fahr.	Appearance of Panels at the End of 15 Cycles
A. W. Beemer......	878^a 520^b	227 a. c.	133	14.5	147	2	Asphalt A 13 cycles	−11	Configurations, several cracks through to aluminum panel. (See Fig. 1 (*a*)). Contracted. (See Fig. 2 (*a*)).
E. H. Berger..........	360^b	234 a. c.	118	18.7	144	2	Asphalt B 13 cycles	0	Fairly smooth, long lines. (See Fig. 1 (*b*)). Checks, cracks through to aluminum panel. (See Fig. 2 (*b*)).
F. H. Gilpin..........	690^a	220 a. c.	140	12	120	3	none	0	Both smooth, black and oxidized. (Not shown in photographs.)
L. Kirschbraun.......	436^b	226 a. c.	140	11.5	147	2	none	−5	Configurations. (See Fig. 1 (*c*)). Badly cracked, but not through to aluminum. (See Fig. 2 (*c*)).
H. E. Lloyd..........	584^b	212 d. c.	150	11.5	142	1	none	−5	Configurations, fluorescent. (See Fig. 1 (*d*)). Checks. (See Fig. 2 (*d*)).
J. S. Miller.........	782^a 462^b	220 a. c.	130	13.5	147	1	none	+1	Black, smooth, faint configurations. (See Fig. 1 (*e*)). Brown, oxidized, perfectly smooth and no configurations. (See Fig. 2 (*e*)).
S. A. Montgomery....	727^a	213 a. c.	153	13.3	130	3	none	−10	Smooth, faint straight lines. (See Fig. 1 (*f*)). Brown, oxidized, checked. (See Fig. 2 (*f*)).
B. H. Roberts.........	368^b	220 d. c.	140^c	9	143	1	Asphalt B 13 cycles	−10	Smooth, straight lines. (See Fig. 1 (*g*)). Curved, split lines. (See Fig. 2 (*g*)).
H. R. Snoke..........	782^a	240 d. c.	138	11.5	136	1	none	−10	Smooth, configurations. (See Fig. 1 (*h*)). Contracted and grooved. (See Fig. 2 (*h*)).
O. G. Strieter........	756^a	240 d. c.	139	11.8	136	1	none	−10	Smooth, configurations. (See Fig. 1 (*i*)). Contracted and grooved. (See Fig. 2 (*i*)).

[a] Total from power line. [b] Across arc. [c] Mercury arc lamp used for light source.

3. A sliding resistance for voltage regulation, instead of the fixed resistance used in many set-ups. The purpose of this resistance is to reduce the line voltage and to supply constant voltage to the lamp. Hence this resistance is inserted between the two kilowatt-hour meters.

4. Ammeter inserted in series to measure current drawn by the arc.

For positive control, recording instruments will no doubt eventually form the standard equipment of every testing machine.

Aside from methods of electric energy control and measurement there is the question of the two kinds of lamps in general use, namely, the alternating current lamp and the direct current lamp.

The difference in these two lamps lies in the fact that in the direct current lamp the positive carbon electrode becomes much hotter than the lower negative carbon. It is this positive electrode which generates most of the light. In the alternating current lamp both electrodes are equally hot and so radiate the same amount of light. However, the alternating current electrodes never become as hot as the positive direct current electrode with the same strength of current and so the light from the alternating current lamp is less intense than that of the direct current lamp. Another minor difference in the two lamps is the intermittent radiation of the alternating current lamp, but since the coöperative tests show great similarity in results these differences seem negligible (compare alternating current panel Fig. 2 (*b*) and direct current panel Fig. 2 (*h*)).

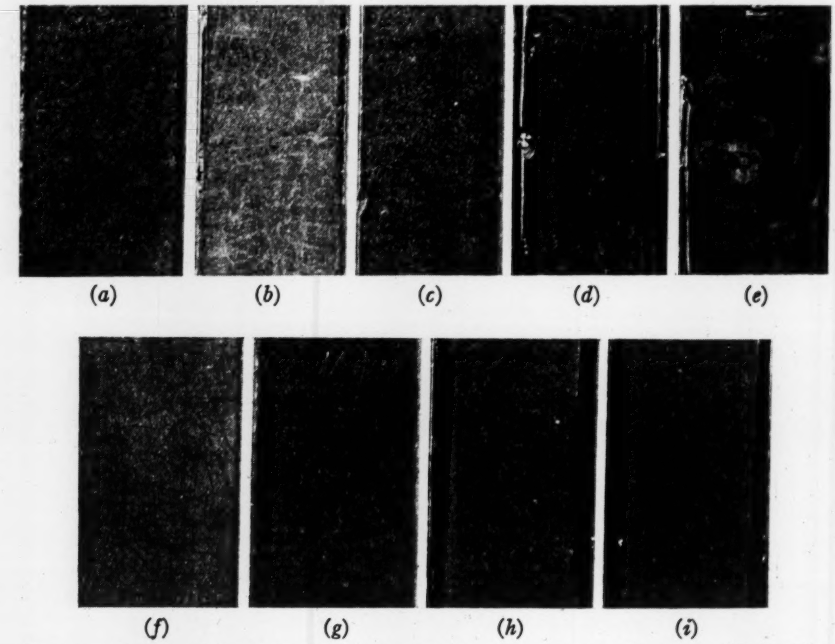

FIG. 1.—Panels of Asphalt A After Accelerated Weathering Tests (See Table I).

There are two ways by which the two types of lamps may be made to give the same result. One is to bring the panels to be exposed closer to the alternating current lamp than to the direct current lamp. The exposure panels in the direct current lamp are placed 15 in. from the carbons and in order to get the same intensity of light and heat they would have to be placed about 11 in. from the source of light in the alternating current lamp. Since this would reduce the number of panels that could be exposed in the cylinders, a more satisfactory method is to increase the amperage of the alternating current lamp. For the direct current lamp 145 volts and 12 to 13 amperes will probably be specified as standard. By allowing the alternating current lamp to draw about 16 to 18 amperes (Fig. 2 (*b*)) with a corresponding voltage, the two lamps should give the same results.

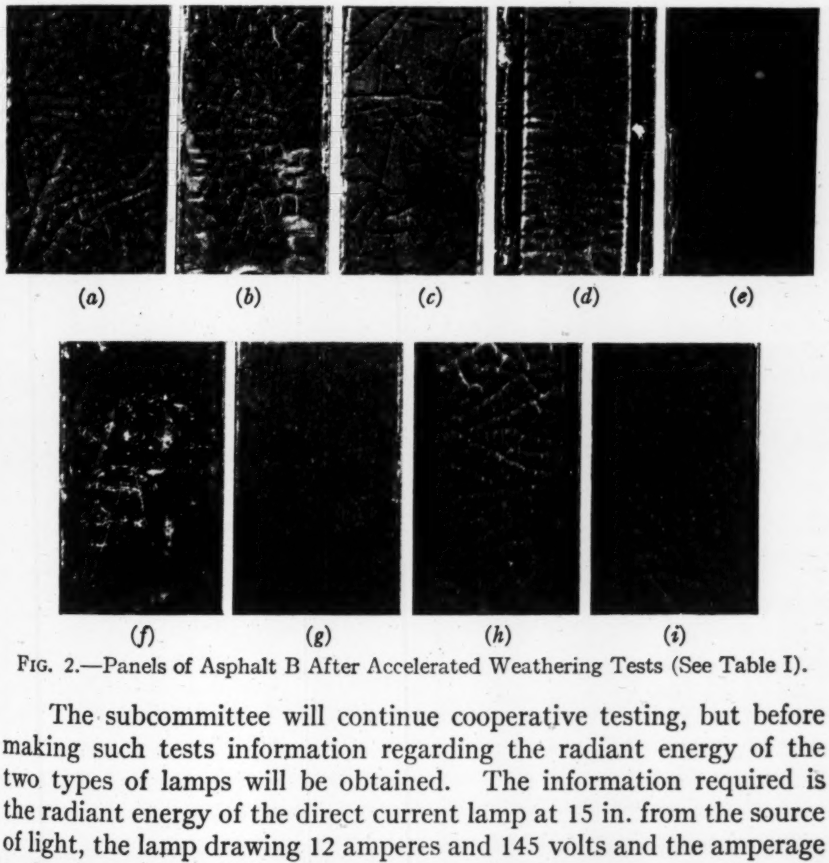

FIG. 2.—Panels of Asphalt B After Accelerated Weathering Tests (See Table I).

The subcommittee will continue cooperative testing, but before making such tests information regarding the radiant energy of the two types of lamps will be obtained. The information required is the radiant energy of the direct current lamp at 15 in. from the source of light, the lamp drawing 12 amperes and 145 volts and the amperage and voltage required for the alternating current lamp to produce the same intensity of light at 15 in. as does the direct current lamp.

Respectfully submitted on behalf of the subcommittee,

O. G. STRIETER,
Chairman.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

Two meetings, each of two days' duration, have been held by the committee and its subcommittees during the year, as follows: At Larchmont, N. Y., October 22 and 23, 1931; and at the Hotel Pennsylvania, New York City, March 3 and 4, 1932. A third meeting will be held at Atlantic City, N. J., during the annual meeting of the Society previous to the presentation of this report.

The subcommittees have advanced their work by holding additional meetings at times other than those at which the main committee met. Subcommittees III on Sheet Insulation, VII on Electrical Tests, and VIII on Insulating Papers and Fabrics have been particularly active in this respect.

The committee has been active in the development of new methods of testing insulating materials, in the improvement of the present standard or tentative standard methods, and in the preliminary drafting of specifications. The scope of the work is covered in detail in the following recommendations affecting methods of test and in the description of the activities of the subcommittees.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation.—Following the writing of test methods for laminated sheet materials used in electrical insulation, the committee encountered a demand from the industry for similar methods for laminated tubes. Considerable experimental work was carried out cooperatively by several laboratories, and methods have been written and verified and are here presented. It is therefore recommended that the proposed Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation, appended hereto,[1] be accepted for publication as tentative.

Proposed Tentative Methods of Grading Natural Mica According to Size, Commercial Quality, and Thickness.—During the past year the committee has actively studied test methods for mica. It has drawn up a set of methods for grading natural mica according to size, commercial quality, and thickness conforming to the usages of the trade. Accordingly the committee recommends that the proposed Tentative Methods of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness, appended hereto,[1] be accepted for publication as tentative.

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[1] See p. 895.—ED.

Proposed Tentative Method of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.—For some time the committee has been studying methods of measuring power factor and dielectric constant at electrical frequencies in the power range (60 cycles) and in the audio-frequency range in the order of 1000 cycles. Several bridge circuits are suitable for this and the committee has selected three of these as suitable on which to base a method. It is, therefore, recommended that the proposed Tentative Method of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles, appearing in Appendix I,[2] be accepted for publication as tentative, and incorporated, with suitable changes in title and scope, in the present Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 - 31 T).[3]

Standard Methods of Testing Molded Insulating Materials Used in Electrical Insulation (D 48 - 30).[4]—Experience with the mechanical strength tests on molded materials has shown that the values obtained in the tensile, compressive, and flexural strength tests depend on the moisture content of the specimens. The committee called attention to this fact in its 1931 annual report[5] and indicated that conditioning of the samples would be necessary. The committee accordingly recommends the following revisions of these methods for publication as tentative:

Section 4 (a).—Change from its present form: namely,

> 4. (*a*) Five specimens shall be tested in the condition in which they are received.

to read as follows:

> 4. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours followed by cool-

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[1] See p. 906.—ED.

[2] This procedure has been incorporated in the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant, see p. 820.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 877 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 642.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 980.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 528 (1931).

ing to room temperature in a desiccator. Five specimens shall be tested at room temperature.

Section 8 (a).—Change the first sentence from its present form: namely,

> 8. (*a*) Five specimens shall be crushed in the condition in which they are received.

to read as follows:

> 8. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours, followed by cooling to room temperature in a desiccator. Five specimens shall be crushed at room temperature.

Section 12 (a).—Change the first sentence from its present form: namely,

> 12. (*a*) Five specimens shall be tested in the condition in which they are received.

to read as follows:

> 12. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours followed by cooling to room temperature in a desiccator. Five specimens shall be tested at room temperature.

In the 1930 annual report of this committee[1] it was recorded that the results of the test for water absorption were so dependant on the temperature of the water that the present range of 10° C. is too great. Accordingly the committee now recommends the following tentative revisions:

Section 22.—Change this section to read as follows by the addition of the italicized figures and the omission of those in brackets:

> 22. Any good chemical balance, a beaker of water at [25° C. ± 5° C. (77° F. ± 9° F.)] *25° C. ± 2° C. (77° F. ± 3.6° F.)*, and an oven of any standard make capable of maintaining a uniform temperature of 100° C. ± 5° C. (212° F. ± 9° F.).

Section 24.—Change the next to the last sentence of this section to read as follows by the addition of the italicized figures and the omission of those in brackets:

> The specimens shall be placed in water, wholly immersed, for 48 hours at a temperature of [25° C. ± 5° C. (77° F. ± 9° F.)] *25° C. ± 2° C. (77° F. ± 3.6° F.)*.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 830 (1930).

Standard Methods of Testing Electrical Insulating Oils (D 117 - 31).[1]—In connection with studies on oils for use in oil circuit breakers the committee feels that it is desirable to include in these methods the steam emulsification test now standard for lubricating oils. Accordingly it recommends the following tentative revision of these methods:

Insert a new Section 17, reading as follows, renumbering the present Sections 17, 18 and 19 as Sections 18, 19 and 20, respectively:

STEAM EMULSIFICATION TEST

17. The steam emulsification test shall be determined in accordance with the Standard Method of Test for Steam Emulsification of Lubricating Oils (A.S.T.M. Designation: D 157) of the American Society for Testing Materials.

Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 - 30 T).[2]—After a careful study of thickness measurements on paper, varnished cloth, and other thin insulating materials the committee has developed a method of adjustment and operation for a machinist's micrometer which should make it the most suitable device for making such measurements. This method has been drawn up to replace the present method which uses a dial micrometer. The committee accordingly recommends that the present apparatus and procedure described in Sections 8 to 11, inclusive, be deleted and replaced by the procedure which appears in Appendix II,[3] with appropriate changes in section numbering.

Considerable research in two laboratories extending over several years has led to the development of a method for aging and testing untreated insulating paper. The committee accordingly recommends that the description appearing in Appendix II,[4] be added to the Tentative Methods D 202 - 30 T under the heading Deterioration as Sections 51 to 55, inclusive.

Tentative Methods of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T).[5]—A test for bonding strength, which determines how thoroughly the laminated layers of laminated sheet material are bonded together, has been developed. The committee recommends that this method, which is given below, be added as an additional test to the present Tentative Methods of Testing

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 104.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1197 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 661.

[3] The revised thickness procedure has been incorporated in the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation, see p. 839.—ED.

[4] The deterioration test procedure has been incorporated in the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation, see p. 853.—ED.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 889 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 680.

Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T) as Sections 34 to 39, inclusive:

BONDING STRENGTH

34. *Apparatus.*—Any standard type of testing machine may be used, providing it is accurate within 1 per cent of the lowest load for which it is used. To this shall be fitted a head containing a 10 mm. steel ball.

35. *Specimens.*—Test specimens shall be 1 in. square, smoothly and accurately cut on a smooth saw.

36. *Procedure.*—Five specimens shall be tested. These shall be placed on edge and the steel ball shall center accurately between the edges and ends of the specimen.

37. *Temperature.*—All tests shall be made at normal room temperature of about 20° C. (68° F.).

38. *Speed of Testing Machine.*—The speed of the cross-head of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

39. *Report.*—The report shall include the following:

(*1*) the thickness of the material; and

(*2*) the load, expressed in pounds or kilograms, required to split the specimen.

Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 - 28 T).[1]—As explained earlier in this report under the revision of Standard Methods of Testing Molded Insulating Materials (D 48 - 30), because of dependence of test results on moisture content the committee recommends the following changes in the Tentative Methods D 256 to require conditioning of the samples for molded insulating material:

Section 4 (a) and *Section 5.*—Add to Section 4 (*a*) and insert in Section 5 after the second sentence the following:

> Specimens of molded insulating material shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours followed by cooling to room temperature in a desiccator. Tests shall be made at room temperature.

Tentative Methods of Test for Resistivity of Insulating Materials (D 257 - 29 T).[2]—The following revisions in these methods are recommended to clarify the testing procedure, and to include the use of conducting paint electrodes:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1021 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 688.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 773 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 693.

Section 4.—Replace the last two sentences which read as follows:

> With a tube, a metal spray or conducting paint may be used. Conducting paint, however, shall not be used on a porous or absorbent material.

by the following:

> A metal spray or a highly conducting paint may be used. The conducting paint shall be chemically inert toward the insulating material and shall not be used on a material so porous or absorbent that appreciable penetration of the material by the conducting paint will take place.
>
> NOTE.—Two suitable conducting paints are as follows:
>
> *Colloidal Graphite Suspended in Distilled Water.*—The paint should have a consistency suitable for application with a camel-hair brush. The applied paint shall be dried for at least one hour in the open air.
>
> *Nitrocellulose Lacquer Containing Graphite.*—Equal proportions of lacquer and thinner shall be thoroughly mixed. To this mixture should be added graphite powder until a consistency is obtained which will barely flow from a soft brush. Enough paint should be prepared for immediate use only.

Section 5.—Change this section from its present form: namely,

> 5. *Measuring Volume and Surface Resistance.*—When both volume and surface resistance are to be measured, there shall be applied to each specimen three electrodes designated as the unguarded electrode, the guarded electrode, and the guard electrode. The method of applying these by means of a paint or spray to a tube is shown in Fig. 1. In the case of a tube specimen, the guard electrode shall be in two parts, one at either end of the tube. In the case of a flat specimen, the guard electrode shall be in the form of a ring surrounding the guarded electrode as shown in Fig. 2. In any case, the distance between the guarded electrode and the guard electrode shall be uniform and as large as 1 cm.

to read as follows:

> 5. *Measuring Volume Resistance.*—When volume resistance is to be measured, there shall usually be applied to each specimen three electrodes designated as the unguarded electrode, the guarded electrode, and the guard electrode. The method of applying these by means of a paint or spray to a tube is shown in Fig. 1. In the case of a tube specimen, the guard electrode shall be in two parts, one at each end of the tube. In the case of a flat specimen, the guard electrode shall be in the form of a ring surrounding the guarded electrode as shown in Fig. 2. In any case, the distance between the guarded electrode and the guard electrode shall be uniform. If the surface resistance is high relative to the volume resistance, the guard electrode may be omitted.

Section 6 (a).—Omit this paragraph which reads as follows:

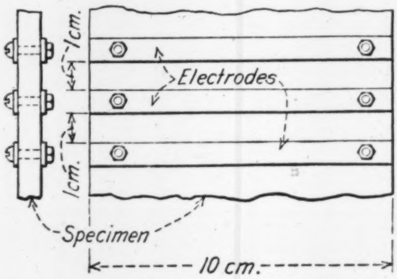
> 6. (*a*) *Measuring Volume Resistance.*—If the surface resistance is high relative to the volume resistance, the guard electrode may be omitted in measuring volume resistance.

Section 6 (b).—Renumber this paragraph as 6 (*a*).

Section 6 (c).—Renumber and change this paragraph from its present form: namely, (*c*) *Measuring Insulation Resistance.*—Disk electrodes, as shown in Fig. 4, may often be advantageously used to measure insulation resistance where it is not necessary or not possible to separate it into volume and surface resistance. They may also be used to measure surface resistance under the same conditions as given in Paragraph (*b*).

to read as follows:

(*b*) When an insulating material is intended for a specific application, it is desirable to apply test electrodes which closely resemble those in actual service. In this case it may not be possible nor desirable to separate the insulation resistance into volume resistance and surface resistance. Figure 4 shows a set of electrodes which have been found suitable for materials intended for mounting binding posts.



Note: The Electrodes are either Tin Foil or other Conducting Material applied to Both Sides of the Specimen. In the Case of Tin Foil, it is wrapped around Metal Bars. After the Bars have been mounted in Position, the Tin Foil is pressed down with a thin Tool along the Edge of the Bar to assure Intimate Contact with the Insulation. The Suggested Dimensions have been found Convenient.

FIG. 1.—Application of Electrodes for Measuring Surface Resistance of Flat, Solid Specimens.

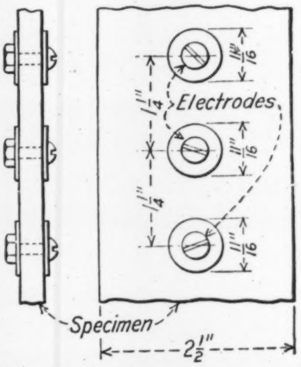


FIG. 2.—Application of Electrodes for Measuring Insulation Resistance of Flat, Solid Specimens.

Figure 3.—Replace the present Fig. 3 by the accompanying Fig. 1. Changes include the dimension of 10 cm. for length of bars and specimen, the 1-cm. dimensions for the space between bars; and revisions in the note.

Figure 4.—Replace the present Fig. 4 by the accompanying Fig. 2.

The following is the result of the letter ballot vote of the committee, which consists of 59 members, on the recommendations made in this report:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation	23	0	13
Tentative Methods of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness	18	0	18
II. TENTATIVE REVISION OF EXISTING STANDARDS			
Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 30)	18	0	18
Standard Methods of Testing Electrical Insulating Oils (D 117 - 31)	24	0	12
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Method of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 - 31 T)	26	0	10
Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 - 30 T)	26	0	10
Tentative Methods of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T)	22	0	14
Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 - 28 T)	19	0	17
Tentative Methods of Test for Resistivity of Insulating Materials (D 257 - 29 T)	26	0	10

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Insulating Varnishes, Paints and Lacquers (C. F. Hanson, chairman):

During the last year Subcommittee I has been carrying on work which is described briefly below:

Acid and Alkali Resistance.—Considerable work has been done in an attempt to develop a test for acid and alkali resistance. Two methods are being tried out with the use of acid solutions and alkali solutions of different concentrations. From the test data obtained, an attempt will be made to standardize on one method and to standardize the concentration of the solutions to be used.

Insulation Resistance.—After quite extensive work, it was decided that this test is too sensitive and delicate for commercial use. It is recognized that it may have merit for research work, but for the time being, attempts to adopt this test commercially have been abandoned.

Proposed New Work.—Experience gained in the past two or three years indicates that the use of insulating varnish may be divided into two classes, as follows: Class 1 for service in which the varnish serves as an insulating film and Class 2 for service in which the varnish serves as an impregnating material becoming a component of a composite insulation.

A varnish which is very adequate for Class 1 service may be very poor for Class 2 service. In recognition of these conditions it seems desirable to develop test methods with these two classes of service in mind. The present Tentative Methods of Testing Insulating Varnishes (D 115 - 30 T) appear to be suitable for varnishes intended for Class 1 service. However, other tests are necessary to determine the suitability of a varnish for Class 2 service.

The additional tests which seem necessary for varnishes intended for Class 2 service are as follows:

Drying Time.—The present method is inadequate. The varnish may dry only on the surface and not within the body of the insulation.

Impregnation.—A test for determining the quality of a varnish to penetrate and fill the fibrous structure and to dry within the structure resulting in a good electrical insulation.

Bonding.—A test for the property of holding together the turns of conductors in a coil especially during the forming operation of the coil.

Elasticity.—A test to determine the property of possessing continuity when subjected to vibrations.

Subcommittee II On Molded Insulating Materials (A. M. Lynn, chairman):

In addition to the recommendations mentioned earlier in this report regarding changes in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 30), and in the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 - 28 T), which have resulted from investigations made by Subcommittee II, studies on the following subjects are now being carried on:

Molding Powders.—Proposed methods of test for determining the principal characteristics of molding powders have been prepared and a classification of the various grades of molding powders to be covered by proposed specifications is being compiled.

Standard Molds for Test Specimens.—As mentioned in last year's report it has been found that the physical characteristics of the standard specimens now specified in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 30) and in the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 - 28 T) may be greatly affected by the variation in the molding cycle obtained with molds of different designs. The subcommittee has, therefore, obtained copies of the designs of a number of test specimen molds now in use by different producers and consumers of molding compounds and is studying these designs with a view to producing molds of standard design which will eliminate the variations in molding specimens that are now encountered.

Impact Fatigue of Plastic Molded Insulating Materials.—The subcommittee is conducting a study on the above characteristics of molded insulating materials with a view to establishing standard methods of test for this property. Preliminary results have been obtained on the impact fatigue of the standard flexural strength test specimen when subjected to repeated impacts and these results are being studied with a view to developing suitable testing equipment and methods of test for this property of molded insulating materials.

Dimensional Tolerances of Impact Test Specimens.—The study of the feasibility of applying the same dimensional tolerances as are now specified for the test specimens in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 30) to the specimens specified in the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 – 28 T) has been continued. While it appears that the impact strength of test specimens of different cross-sectional areas equivalent to the variation which would be obtained by the use of the proposed tolerances may be satisfactorily corrected by the use of a factor, bd^2, the subcommittee believes that further consideration of this question is necessary before including such a correction. The Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 – 28 T), which have been established as tentative for more than three years, will be retained in the tentative status for another year pending completion of this investigation.

Subcommittee III on Plates, Tubes and Rods (Dean Harvey, chairman):

Section A on Compressibility.—Four laboratories have purchased the new compressibility testing machine designed by the Bell Telephone Laboratories. Tests are being made, varying the size of pressure foot, size of specimen and the pressure.

Section B on Rods and Tubes.—Proposed Methods of Testing Laminated Tubes Used in Electrical Insulation, as mentioned earlier in the report, have been developed and are being submitted for publication as tentative. These methods cover compressive strength, water absorption, dielectric strength and density, and refer to the Tentative Methods D 150 – 31 T for determining power factor and dielectric constant.

A test for tensile strength has been outlined, but some details have not yet been completed. Methods of test for rods are being studied.

Section C on Dielectric Strength.—An extensive investigation of the effect of humidity on the dielectric strength of sheet materials has been made. Several grades of laminated sheets $\frac{1}{16}$ in. in thickness have been tested after 96 hours' exposure to humidities of 40, 70, 85, and 100 per cent. Other samples have been tested after immersion in water for 1, 4, 7, 14, and 30 days, respectively. Tests are being made after exposure of 1, 4, 7, 14, and 30 days at 100 per cent humidity. The effect upon different thicknesses is being determined by exposing specimens $\frac{1}{64}$, $\frac{1}{16}$, $\frac{1}{8}$, and $\frac{1}{4}$ in. in thickness for 96 hours at 100 per cent humidity.

Section D on Conditioning.—The effect of conditioning upon the flexural strength of two grades of laminated sheets has been determined. Six laboratories have cooperated in the work. Four thicknesses were tested, $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ in. Tests were made as received, and after exposure for 96 hours to 35, 65, and 90 per cent humidity. These tests have shown that the strength is considerably affected under certain conditions of humidity. A study is now being made to determine the proper conditioning of specimens before test.

Section E on Arc Resistance.—A new method of test for arc resistance has been outlined, and the apparatus has been made and preliminary tests carried on by four laboratories. Samples are being distributed for round robin tests.

Section F on Impact and Impact Fatigue.—A fundamental study of impact fatigue tests is being made by Mr. H. M. Richardson of the General Electric Co., in connection with this committee work. It is expected that this study will determine the limiting dynamic stresses (endurance limit) of various materials; the relation between endurance limit, flexural strength and single blow impact strength, and the weakening effect of a notch in the specimen.

Section G on Bonding Strength.—A method of test for bonding strength of laminated sheets $\frac{3}{16}$ in. in thickness or over has been developed and, as mentioned earlier in this report, is being recommended as an addition to the Tentative Methods of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T). Work is being continued to provide a method of test for thinner sheets, but thus far no satisfactory method has been found.

Sections H on Punching Quality and I on Insulation Resistance.—These sections have been organized at the request of the Technical Committee on Laminated Products of the National Electrical Manufacturers' Association to prepare methods of test for sheets to be added the Tentative Methods of Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 31 T). The work on these two subjects is just being undertaken. Section I is working in cooperation with Subcommittee VII on Electrical Tests.

Subcommittee IV on Insulating Mineral Oils (E. A. Snyder, chairman):

In addition to recommending the inclusion of the Standard Method of Test for Steam Emulsion of Lubricating Oils (D 157 – 28) as a tentative revision, as mentioned earlier in the report, for inclusion in the Standard Methods of Testing Electrical Insulating Oils (D 117 – 31) for application chiefly to the testing of switch oils, the subcommittee during the year has made the following progress in the study of other problems on insulating oils:

Neutralization Number.—During the year some progress has been made in the further study of methods of electrometric titration for determining the neutralization number of oils. The two methods given in the 1930 report of the committee[1] have had some further study and recently the section studying this problem has been reorganized and is planning to give this subject more vigorous study during the coming year. A subsection has been appointed to discuss this matter with representatives of Committee D-2 on Petroleum Products and Lubricants and extensive research work is planned for the coming year.

A bibliography covering electrotitrometric procedures used by this section in preparing methods for trial on oils is as follows:

Proposed Method of Test for Neutralization Number of Petroleum Oil, Titration by Electrometric Method, *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 282 (1925).

H. Seltz and D. S. McKinney, "Quinhydrone Electrode in Amyl Alcohol Solutions," *Industrial and Engineering Chemistry*, Vol. 20, p. 542 (1928).

H. Seltz and L. Silverman, "Determination of Acidity of Oils and Fats by the Quinhydrone Electrode in Non-Aqueous Solutions," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 2, p. 1 (1930).

N. H. Furman, "Potentiometric Titrations—A Review and a Report of Progress," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 2, p. 213 (1930).

B. L. Clarke and L. A. Wooten, "Null-Point Method of Potentiometric Titration for Determining Acid and Alkali in Paper," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 2, p. 385 (1930).

R. N. Evans and J. E. Davenport, "Potentiometric Determination of Acidity in Insulating Oils," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 3, p. 82 (1931).

J. L. R. Morgan, O. M. Lammert and M. A. Campbell, "The Quinhydrone Electrode," *Journal*, Am. Chemical Soc., Vol. 53, pp. 454, 597 and 2154 (1931).

V. K. La Mer and H. C. Downes, "Acidity in Non-Aqueous Solvents—Conductimetric and Electrometric Titrations of Acids and Bases in Benzene," *Journal*, Am. Chemical Soc., Vol. 53, p. 888 (1931).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 841 (1930).

Sludge Test.—The research work laid out for the development of a suitable method for determining sludging properties of insulating oils and referred to in the 1930 report of the committee has been completed. On the basis of the results obtained on this preliminary program, a new program has been laid out for this year, narrowing considerably the field of research on this problem. Four samples of oils have been distributed to cooperating members of this section and the test procedure outlined for all of the members to follow. This work has been partially completed but is not far enough advanced to enable the committee to draw conclusions and make definite recommendations. It is hoped that this program will be completed in the near future so that a report of the two years' study can be prepared for the next annual report.

Short-Time Sludge Tests.—The development of a short-time sludge test for use in controlling the uniformity of shipments of one type of oil has been prepared. This proposed method is a modification of the Sligh test. Samples of oil have been distributed to the section members working on this test and the following results have been obtained by three cooperating laboratories:

NEUTRALIZATION NUMBER OF OXIDIZED OIL BY MODIFIED SLIGH TEST

SAMPLE	LABORATORY NO. 1	LABORATORY NO. 2	LABORATORY NO. 3
No. 1......	7.8	7.9	6.72
No. 2......	18.5	19.5	14.12
No. 3......	14.4	15.8	11.72
No. 4......	32.1	41.3	28.55

NEUTRALIZATION NUMBER OF OXIDIZED OIL BY SLIGH TEST

SAMPLE	LABORATORY NO. 1	LABORATORY NO. 2	LABORATORY NO. 3
No. 1......	0.98 mg. of KOH per g.	1.37 mg. of KOH per g.	1.39 mg. of KOH per g.
No. 2......	0.77 mg. of KOH per g.	1.18 mg. of KOH per g.	1.06 mg. of KOH per g.
No. 3......	0.62 mg. of KOH per g.	1.23 mg. of KOH per g.	1.34 mg. of KOH per g.
No. 4......	0.55 mg. of KOH per g.	1.00 mg. of KOH per g.	0.93 mg. of KOH per g.

These results show that fairly uniform agreement is obtained by the various laboratories. However, there are several other laboratories cooperating in this work, whose results have not yet been obtained, and the subcommittee believed it would be desirable to hold this matter over another year before making a proposal to include this method as a tentative method for publication this year. The subcommittee plans to study this method further in cooperation with Committee D-2 on Petroleum Products and Lubricants.

Saponification Number.—The section studying the development of a saponification number for insulating oils has distributed nine samples to various members of the subcommittee for tests by the

Standard Method of Test for Saponification Number (D 94 – 28) and also by other methods proposed for study by this section. Definite progress is being made in these studies and it is hoped that by next year the subcommittee may be in a position to recommend a tentative method for measuring the saponification number of insulating oils.

Circuit Breaker Oils.—During the year a section of Subcommittee IV has been reviewing the various methods of test proposed for examining circuit breaker oils and has definitely recommended the inclusion of the Standard Method of Test for Steam Emulsion of Lubricating Oils (D 157 – 28) for use in determining the quality of circuit breaker oils.

The subcommittee has also considered the development of a method for measuring low-temperature viscosities of circuit breaker oils but the lack of a suitable apparatus for making a test of this character has mitigated against the development of a standard method. The methods considered have all been of such intricate research character that the subcommittee has felt them to be unsuitable for a standard acceptance test. The subcommittee has been awaiting the appearance of the viscosity-temperature chart[1] being prepared by Committee D-2, with the thought that this chart may be adequate for the purpose of interpolating the low-temperature viscosities of switch oils. The subcommittee proposes to give this matter further consideration during the coming year.

During the year the subcommittee also made some study of methods for determining the rate of throwing water and carbon out of solution or suspension. It has not progressed far enough with this study to make any definite recommendations.

Moisture in Insulating Oils.—The subcommittee is still carrying on the study of this subject as referred to in last year's report and is working along the lines that will develop both a chemical and mechanical test for this property. The work has not progressed to such a point where the subcommittee feels that a definite report can be made.

Subcommittee V on Ceramic Products (*Porcelain, Glass, Etc.*) (L. E. Barringer, chairman):

A test method for determining the effect of heating and cooling on the mechanical strength of porcelain and also a water absorption test requiring less time than required in the present method are under consideration. This subcommittee is also studying methods of test to apply more specifically to dry-process porcelain.

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[1] The Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 – 32 T) was accepted for publication by the Society through Committee E-10 on Standards, March 8, 1932. Copies of the chart are obtainable separately or in pads of 25 each from the American Society for Testing Materials.

Subcommittee VI on Solid Filling, and Treating Compound (J. M. Wilson, chairman):

At the time of the reorganization of Subcommittee VI in June, 1931, the results of a questionnaire to members of this subcommittee indicated the need for modification of certain tests outlined in the Tentative Methods of Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 – 29 T), and also the need for test methods for certain other properties not covered by these tentative methods. The work of the subcommittee now in progress and planned is as follows:

Section A on Coefficient of Expansion.—A substantial opinion indicated that the procedure in the present Tentative Method D 176 – 29 T for the determination of the coefficient of expansion, in the case of asphalts, was not only too complicated and time consuming but did not give results of an accuracy commensurate with the time and effort required. This section was set up to review this method and to consider such modifications as appeared necessary to increase the accuracy and shorten the time required. Furthermore, based on the results obtained by the U. S. Bureau of Standards, it appears that straight asphalts have practically a constant coefficient of expansion and that such sizable differences as are sometimes noted were due to entrapped air or gas. The present tentative method and other methods which appear promising are being actively studied.

Section B on Determination of Insulation Resistance - Temperature Characteristics.—The development of a suitable method of test for determining the insulation resistance - temperature characteristics of solid filling and treating compounds has resulted in a review of the methods used by those making this test. Based on this review, a proposed design of compound holder and a tentative procedure for carrying on the test are now being studied. As soon as an agreement is reached as to the design of holder and procedure to be followed, tests will be inaugurated.

Section C on Determination of Dielectric Constant.—This section is concerned with the type and method of preparation of a specimen and such other details as are necessary to obtain reproducible results when measurements for dielectric constant are made in the usual manner. Round robin tests have been carried out by several laboratories with two types of specimens on a wide range of compounds. The types of specimens used were the disk type and the cell type. Determinations at 60 cycles and at 1000 cycles were made in all cases at room temperature, and the results obtained were in very close agreement with the exception that certain of the materials which solidify above room temperature appeared to have pulled away from the wall of the cell. In view of this it is planned to carry on further tests using the cell method in which the material would be held at a higher temperature than room temperature, probably 105° C. or 110° C., so as to insure a liquid state in the case of those materials which become solid at a more or less definite temperature with an accompanying change in volume.

Section D on Viscosity Determinations of Higher Melting Asphalts.—As a result of difficulties encountered by members in making viscosity determinations on higher melting asphaltic compounds, which in some cases appeared to be outside the range of the commonly used Saybolt Furol Viscosimeter, this section was organized at the March meeting of the committee for the purpose of determining whether or not some other type of standard viscosimeter or perhaps a modification of a standard viscosimeter would be better suited for this class of material.

The experience obtained with the Tentative Methods of Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 - 29 T), as noted briefly above, has indicated the need for some revision. However, the work of the subcommittee has not progressed sufficiently to warrant the recommendation of any changes at this time. It is therefore recommended that the methods in their present form be continued as tentative.

Subcommittee VII on Electrical Tests (E. S. Lee, chairman):

The completed work for the year has resulted in recommendations for revision of the Tentative Methods of Test for Resistivity of Insulating Materials (D 257 - 29 T) to clarify the method and to include the use of conducting paint electrodes. Also, a method for measuring power factor and dielectric constant of solid electrical insulating materials at frequencies in the order of 1000 cycles is recommended for acceptance as tentative, as mentioned earlier in this report. The following work by the sections of this subcommittee is in progress:

Section B on Power Factor of Liquid Insulation and Section C on Power Factor of Solid Insulation are working together on a method of measuring power factor at 60 cycles.

Section C is working on methods of measuring power factor at frequencies in the order of 10 to 20 megacycles. It is also studying the measurement of power factor of mica.

Section D on Thermal Conductivity is studying means of eliminating thermal contact difficulties at the surfaces of test specimens.

Subcommittee VIII on Insulating Papers and Fabrics (Treated and Untreated) (H. N. Van Deusen, chairman):

In addition to the work which Subcommittee VIII has done leading to the recommendations mentioned earlier in the report relative to the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 – 30 T), the subcommittee has been carrying on work along other lines which are mentioned briefly, as follows:

Insulating Paper.—Methods of determining the acidity of papers which have been submitted as alternates or substitutes for the procedure in the present Tentative Methods D 202 – 30 T are under consideration. Considerable further laboratory study will be necessary before any of these methods can be recommended for acceptance.

Work is being continued on a testing machine which has been developed for determining the edge tearing strength of untreated papers. Efforts are being made to evaluate this device by laboratory trial using different grades of paper.

Test methods have been developed for condenser tissue but further laboratory study is necessary before they can be recommended for acceptance.

Work is being continued on the folding endurance tester of the Massachusetts Institute of Technology with the object of standardizing this type of test.

Varnished Cloths and Tapes.—The subcommittee is working on the preparation of tentative specifications for black bias-cut varnished cloth tape for use in insulating bus bars, generators, transformers, wires and cables, and similar apparatus and appliances. It is expected that the preparation of these specifications may disclose the need for further revision of the Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 29 T), and they are therefore being continued as tentative for another year.

Methods of measuring thickness of varnished cloths and tapes with the ratchet type of micrometer, in accordance with the method of procedure previously mentioned in connection with the Tentative Methods D 202 – 30 T, are being investigated.

Flexible Varnished Tubing.—Methods of testing flexible varnished tubing are in preparation by the committee. Specifications for this material are also in course of preparation.

Subcommittee IX on Mica Products (M. P. Davis, chairman):

Attention has been devoted to the study of test methods and specifications for mica for capacitor manufacture and for built-up pasted mica for general insulating purposes.[1] This work has resulted in the preparation of proposed Tentative Methods of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness, appended hereto,[2] which are being recommended for publication as tentative. Active work will be continued until complete test methods and specifications for both classifications of mica are available.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

Since the preparation of the earlier part of this report, work in the committee has resulted in the preparation of three new tentative methods, and also an addition to one of the proposed tentative methods contained in the report and in minor changes to two existing tentative standards. It is the intention of the committee to present these to the Society in August through Committee E-10 on Standards. They are mentioned at this time only as a matter of information. The titles of the new proposed methods are:

Tentative Methods of Test for Pasted Mica Used in Electrical Insulation;[1]

Tentative Methods for Testing Flexible Varnished Tubing Used for Electrical Insulation;[3] and

Tentative Methods of Testing Laminated Round Rods Used in Electrical Insulation.[4]

A test for tensile strength is ready to be added to the Proposed Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation. The minor changes are in the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 31 T) and in Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 29 T).

This report has been submitted to letter ballot of the committee, which consists of 59 members; 32 members returned their ballots, of whom 22 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. L. CURTIS,
Chairman.

J. A. SCOTT,
Secretary.

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[1] See p. 911 —ED.
[2] See p. 906.—ED.
[3] See p. 902.—ED.
[4] See p. 899.—ED.

EDITORIAL NOTE

The proposed Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation and Methods of Test for Grading Natural Mica According to Size, Commercial Quality, and Thickness were accepted for publication as tentative and appear on pages 895 and 906, respectively.

The proposed tentative revisions of the Standard Methods of Testing Molded Materials Used for Electrical Insulation and Testing Electrical Insulating Oils were accepted for publication as tentative and appear on pages 1020 and 1021, respectively.

The proposed revisions of the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles, Testing Untreated Paper Used in Electrical Insulation, Testing Laminated Sheet Materials Used in Electrical Insulation, Testing Electrical Insulating Materials for Resistance to Impact and Test for Resistivity of Insulating Materials were accepted. The methods as revised appear on pages 820, 837, 860, 868 and 873, respectively.

The proposed Tentative Methods of Testing Pasted Mica Used in Electrical Insulation, of Testing Laminated Round Rods Used in Electrical Insulation, and of Testing Flexible Varnished Tubing Used for Electrical Insulation, referred to in the report, were subsequently accepted for publication as tentative on August 11, 1932, by Committee E-10 on Standards and appear on pages 911, 899 and 902, respectively.

Revisions of the Tentative Methods of Testing Laminated Tubes Used in Electrical Insulation, of Testing Sheet and Tape Insulating Materials for Dielectric Strength and of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation were accepted on August 11, 1932, by Committee E-10 on Standards. The methods in their revised form appear on pages 895, 810 and 886, respectively.

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS

Committee D-11 on Rubber Products has held two meetings during the year in addition to the one held during the 1931 annual meeting. One was in New York City on November 5, 1931, and the other at Cleveland, Ohio, on March 8, 1932, in connection with the Spring Group Meetings of A.S.T.M. Committees. The committee also sponsored the technical program consisting of a very interesting Symposium on Rubber which was presented in two sessions at the Cleveland Regional Meeting on March 9, 1932. The twelve papers dealing with the manufacture of rubber products and the properties of rubber as an engineering material were of great value and contributed largely to the success of the Regional Meeting.

At the meeting in November, the committee accepted with regret the resignation of its chairman, Mr. W. B. Wiegand, who was obliged to relinquish his office of chairman because of press of other duties. The committee has since been under the leadership of its vice-chairman, Mr. C. R. Boggs, who was unanimously chosen acting chairman.

The committee has given considerable attention during the year to plans for making its service more valuable to industry. An open discussion at the November meeting emphasized the opinion that in the present state of the rubber industry less attention should be given to the preparation of detailed materials specifications for rubber products than to the development and standardization of satisfactory methods of test. Special importance is attached to the development of tests of the performance type for ultimate use in purchase specifications. The committee has accordingly recorded the policy by formal vote of temporarily discontinuing work on the preparation of product specifications and confining its activities for the present to the development of satisfactory standard methods of test with particular emphasis on performance tests.

Committee D-11 has been ably represented on the General Membership Committee of the Society by Mr. D. C. Scott. Mr. Scott has been very active in the work of endeavoring to increase the Society's membership. Under present conditions this is a difficult task. During the year four members have been added to the committee and one has resigned, leaving a net gain of three members.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee concerning standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item.

Proposed Tentative Standards.—The committee recommends for publication as tentative the following two new tentative specifications as appended hereto:

Proposed Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound.[1]—These specifications are considered to represent an important step forward in the preparation of satisfactory rubber product specifications since no requirements are included as to the composition of the rubber compound, and the quality is evaluated solely on the basis of test results. The existing Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 - 31 T) cover two classes of rubber insulating compounds. One of these, termed the class A compound, does not contain organic accelerators nor anti-oxidants, while in the other, called class AO compound, use of accelerators and anti-oxidants is permitted. The specification requirements for both of these classes are of the materials type. In the new specifications a third type of rubber compound is permitted which will be known as the performance rubber compound. As early as 1927 the need for these specifications was discussed in the committee. In March, 1928, a section of Subcommittee V on Insulated Wire and Cable was appointed to develop performance tests for the rubber on insulated wire. The proposed specifications are the outgrowth of the work of this section.

Proposed Tentative Specifications for Friction Tape for General Use for Electrical Purposes.[2]—These specifications are intended to supersede the existing Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 - 28),[3] which are recommended to be withdrawn. The reason for this action is that the present specifications have been subject to considerable criticism. Among the objections may be mentioned comments that the requirements permitted the acceptance of tape having little initial adhesiveness, that the oven test was not clear in its intent, was too severe and did not correctly forecast the life of the tape, that the dielectric strength test should be studied and improved; also that the sampling requirements in the case of large orders, required too many specimens, and that the requirements in regard to weight and yardage were not sufficiently clear-cut and definite. In view of these objections, the specifications have been entirely rewritten and the proposed specifications, appended hereto,[1] represent an improvement in quality through more rigid requirements.

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[1] See p. 916.—ED.

[2] See p. 926.—ED.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1036.

Revision of Tentative Standard.—The committee recommends that the Tentative Specifications for Rubber Insulating Tape (D 119–28 T)[2] be completely revised as appended hereto.[3] The reason for this recommendation is that the present tentative specifications have been subject to considerable criticism, as follows: (1) The tensile strength should be determined using standard dumb-bell samples and the specified limits correspondingly increased; (2) Maximum as well as minimum strength at rupture should be given; (3) A section fixing a minimum of elasticity should be included; (4) The dielectric strength tests should be made by means other than using the brass ball sphere electrodes specified. The rewritten specifications represent an improvement over the present tentative specifications which they replace.

Advancement of Tentative Standard to Standard.—It is recommended that the Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 31 T)[4] be advanced to standard. No criticism has been received of these methods while in the tentative status and they are believed to be entirely satisfactory. These methods replace Sections 1 to 47 of the present Standard Methods of Testing Rubber Products (D 15 – 24) which sections are recommended to be withdrawn, as mentioned later in this report.

Proposed Revision of Standard.—The committee recommends the advancement to standard of the tentative revision proposed in 1931[5] in the sections covering Physical Tests of the Standard Methods of Testing Rubber Products (D 15 – 24).[6] Since Sections 1 to 47 of these methods covering Chemical Tests will be withdrawn in view of the advancement to standard, as mentioned earlier in this report, of the Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 31 T), it is proposed to change the title of Methods D 15 to read "Standard Methods of Physical Testing of Rubber Products" and to renumber the present Sections 48 to 63 as Sections 1 to 16.

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[1] See p. 926.–ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1068 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 765.

[3] See p. 930.–ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 947 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 769.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1067 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 933.

[6] 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

In this way the methods of chemical analysis will be separated from the methods of physical testing for rubber products which is considered desirable since the two have very little in common and are frequently carried out in separate laboratories. Furthermore, it is believed that the recommended changes in the methods of physical testing represent a definite improvement in line with the advance of the art.

The above recommendations have been submitted to letter ballot in the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound	21	0	8
Tentative Specifications for Friction Tape for General Use for Electrical Purposes	22	0	7
II. REVISION OF TENTATIVE STANDARD			
Tentative Specifications for Rubber Insulating Tape (D 119 - 28 T)	22	2	5
III. ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD			
Tentative Methods of Chemical Analysis of Rubber Products (D 297 - 31 T)	30	0	3
IV. ADVANCEMENT TO STANDARD OF TENTATIVE REVISIONS OF STANDARD			
Standard Methods of Testing Rubber Products (D 15 - 24)	31	0	2
V. WITHDRAWAL OF STANDARD			
Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 - 28)	24	0	5

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Mechanical Rubber Hose (E. G. Kimmich, chairman).—The subcommittee reported last year that a section had been organized to prepare specifications covering general methods of test for the various kinds of wrapped and braided hose. This section submitted to the subcommittee a proposed tentative standard on methods of testing hose but upon further study this standard was found to conflict with the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 - 31 T) and to require revision in other particulars. The subcommittee has found that the present A.S.T.M. specifications and methods of test relating to hose, with the exception of those for cotton rubber-lined fire hose, are not widely used for the following reasons:

1. The test methods are not properly designed to completely evaluate hose for actual service conditions.

2. The range of service conditions cannot be adequately covered by one or two standards for each general class of service. For instance, hose for use with pneumatic tools is made by two distinct methods

with many variations of each and the same manufacturers find it necessary to design hose of each type in at least three grades: namely, (*a*) for ordinary factory maintenance; (*b*) for structural steel work of buildings and ships; and (*c*) for excavating quarry and mine work.

3. The limited use of the standards results in hose made to A.S.T.M. standards being produced in quantities so small as to cause excessively high cost of manufacture.

The subcommittee has, therefore, instructed the Section on Test Methods to prepare two tentative test methods, one for wrapped hose and one for braided hose, which are to include performance type tests and apparatus in so far as possible. When these test methods are completed, it is the intention of the subcommittee to submit them for the purpose of replacing the following standards:

Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 - 24);
Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 - 24);
Specifications for Wrapped Cold Water Hose (D 177 - 24);
Methods of Testing Rubber Products (D 15 - 24), certain sections;
Tentative Specifications for Steam Hose (D 54 - 31 T).

Subcommittee IV on Protection of Persons from Electric Shock (H. S. Vassar, chairman).—This subcommittee has prepared in preliminary form specifications for linemen's blankets in compliance with requests which it has received from consumers and manufacturers of this product, and expects to have these in shape for submission to the Society in the near future.

Subcommittee V on Insulated Wire and Cable (C. B. Martin, chairman).—This subcommittee has prepared proposed Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound, as mentioned earlier in this report, which are being recommended to the Society for acceptance as tentative. The subcommittee has been very active throughout the year and its interest in the work well sustained. Through its Section on Braids it is also actively working on the table on thickness and weave of cotton braid appearing in Part D on Cotton Braid of the Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 - 31 T). This section is cooperating with the Technical Committee on Braids of the National Electrical Manufacturers' Association and expects to recommend a new braid table in the Tentative Specifications D 27 - 31 T which will be in entire agreement with the requirements for the higher quality Class A Braid of the N. E. M. A.

Subcommittee IX on Insulating Tape (J. M. Bierer, chairman).—This subcommittee has been very active during the year in revising the Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 – 28) and the Tentative Specifications for Rubber Insulating Tape (D 119 – 28 T). The results of this work are presented in the proposed new Tentative Specifications for Friction Tape for General Use for Electrical Purposes and in the proposed revised Tentative Specifications for Rubber Insulating Tape, appended hereto.[1]

Subcommittee XIV on Abrasion Tests for Rubber Products (H. A. Depew, chairman).—Subcommittee XIV has agreed that its activities should aim toward the development of engineering knowledge regarding abrasion. Under present conditions it is impractical to carry out further cooperative testing programs but a plan for future work should be worked out. To this end, the subcommittee has circulated a questionnaire in order to secure information as to the general lines along which the subcommittee should work. The questionnaire included suggestions for several test machines and solicited criticisms and further suggestions.

Subcommittee XV on Life Tests for Rubber Products (R. A. Schatzel, chairman).—Previous reports of Committee D-11 have contained references to the series of aging tests which were started by this subcommittee in 1928 for the purpose of securing data on the correlation of the Geer oven and the Bierer-Davis bomb accelerated aging tests with natural aging both in the dark and exposed to the weather. Three types of compounds were used, one a pure gum stock, another a high-grade black tread and the third a reclaim tread compound. The stocks were factory mixed, sheeted on the calendar and test sheets were vulcanized at two cures. The test sheets were distributed among thirteen laboratories for testing according to a prescribed procedure. Conditions of milling, curing, testing and aging were all defined as completely as possible.

The natural aging tests have extended over a period of three years and a large amount of data has been accumulated. In all, this program involved the preparation and testing of 1350 cured sheets and the pulling of over 5000 dumb-bell test strips. The results of this work have been summarized by the subcommittee in a 37-page report that has been circulated within the subcommittee which is not yet ready to report any definite conclusions as to the correlation results. The subcommittee feels that a complete analysis by a small group must be carried out for proper interpretation of the data and has appointed a section consisting of Messrs. H. A. Depew, N. A. Shepard, R. P. Dinsmore and A. W. Carpenter to make this analysis. Meanwhile, it has been decided to carry out a schedule of additional tests using a single compound with the unaged samples cured in a single laboratory. These tests are to follow the test procedure of the American Chemical Society and twelve laboratories have agreed to cooperate in making the tests.

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[1] See pp. 926 and 930, respectively.—ED.

This subcommittee also has before it the project of preparing standard procedures for carrying out Geer oven aging and oxygen bomb tests. In this project it is cooperating with the Physical Test Committee of the Rubber Division, American Chemical Society.

Subcommittee XVII on Rubber Products for Absorbing Vibration (F. D. Abbott, chairman).—The Hardness Section of this subcommittee has before it the matter of adapting the approved instrument and the Tentative Method of Test for Hardness of Rubber (D 314 - 31 T) to the testing of very soft rubbers as well as true hard rubber. It is also engaged in the preparation of comparison curves between results with the A.S.T.M. instrument and other hardness measuring devices in current use. It is expected that as a result of this work the A.S.T.M. hardness tester will find wider application as a standard instrument.

The Section on Flow Testing reports progress in its work on the development of a standard method and instrument for determining compression set. As a result of its cooperation with the instrument makers, one device for making this test is now commercially available and others are in process of development. Standardization has not yet been developed to a point where the subcommittee is ready to make any definite recommendations, although it is anticipated that a standard method for testing cold flow of rubber compounds can be prepared in the near future.

In connection with rubber products used for absorbing vibration, the questions of the adhesion of rubber to metals and the effect of repeated compression on rubber compounds are of great importance. The subcommittee has formed two new sections for the study of these questions.

Subcommittee XVIII on Dynamic Fatigue Testing for Rubber Products (W. L. Sturtevant, chairman).—This subcommittee has formed two sections. The first will consist of three members and will be known as the Section on Ply Separation. It has been instructed to prepare a tentative method for conducting separation tests on plied rubber and fabric materials using the Scott flexing machine.

The second section will consist of five members and will be known as the Section on Flex Cracking. It has been instructed to study methods of flex testing rubber stocks without fabric. The subcommittee recognizes the fact that a number of flex testing machines and methods have yielded valuable results but that the methods in use are not standardized. It believes that standardization would make the results more valuable but it appreciates the difficulty of securing precise results in this type of test and proposes adequately to surround any method which is developed with precautions that will discourage improper use of the method without interfering with the benefits to be derived from standardized procedure.

This report has been submitted to letter ballot of the committee which consists of 70 members; 33 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. R. BOGGS,
Acting-Chairman.

ARTHUR W. CARPENTER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound were accepted for publication as tentative and appear on page 916. The required favorable letter ballot on the addition to the specifications of requirements covering cotton braid, proposed on the floor of the annual meeting, see Summary of Proceedings p. 20, was not obtained.

The proposed Tentative Specifications for Friction Tape for General Use for Electrical Purposes, to replace the Standard Specifications for Friction Tape for General Use for Electrical Purposes, were accepted for publication as tentative and appear on page 926. The withdrawal of the standard specifications was approved.

The proposed revision of the Tentative Specifications for Rubber Insulating Tape, as further revised on the floor of the annual meeting, see Summary of Proceedings, page 20, was accepted. The specifications in their revised form appear on page 930.

The advancement to standard of the Tentative Methods of Chemical Analysis of Rubber Products was approved at the annual meeting and the methods were subsequently adopted as standard by letter ballot of the Society on September 1, 1932. The methods appear in the 1932 Supplement to Book of A.S.T.M. Standards, page 49.

The advancement to standard of the tentative revision of the Standard Methods of Testing Rubber Products was approved at the annual meeting and the revisions were subsequently adopted as standard by letter ballot of the Society on September 1, 1932. The methods in their revised form appear in the 1932 Supplement to Book of A.S.T.M. Standards, page 73.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials has held its two customary interim meetings since the 1931 annual meeting of the Society. The fall meeting was held at the U. S. Bureau of Standards, Washington, D. C., on October 15 and 16, 1931, and the spring meeting at the Hotel Biltmore, Providence, R. I., on March 10 and 11, 1932. A third meeting will be held at Atlantic City, N. J., in conjunction with the annual meeting of the Society in June. The number of members and guests in attendance at the fall and spring meetings was 67 and 82, respectively, which represents a substantial increase over the preceding year. The Advisory Committee held a session at each meeting.

The interim meetings have been made more valuable by papers which have been presented on the following subjects:

"The Value of Specifications to Industry," by D. B. Wainwright, Jr.;

"Thickness Measurements," by W. E. Emley;

"Control of Humidity in Small Enclosed Spaces," by F. T. Carson;

"Most Textile Secrets are 'Undiscovered' Knowledge," by C. H. Clark;

"Investigation of Methods for Conditioning Rayon Fabrics for Wet Tensile Strength," by Alexis Sommaripa;

"Testing Knit Goods," by G. B. Haven;

"Some Factors Influencing the Spinning Quality of Cotton," by H. H. Willis.

The committee is sponsoring a session at the annual meeting to be devoted exclusively to textile materials at which the following papers are to be read and discussed:[1]

"A Machine Test on the Durability of Manila Rope," by N. C. Wiley;

"Enzyme Action in the Textile Industries," by W. F. Edwards;

"Atmospheric Control in the Textile Industry," by R. H. Brown;

"Asbestos Textiles," by C. K. Dillingham;

"Some Aspects of the Structure and Properties of the Rayons," by H. DeW. Smith;

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, pp. 705 to 777 (1932).

"The Suter-Webb Cotton Fiber Duplex Sorter and the Resulting Method of Length-Variability Measurements," by R. W. Webb;

"Colorimeter and Method Employed in the Color Testing of Cotton," by Dorothy Nickerson.

This program has been arranged by the Subcommittee on Papers of which Mr. Dean Harvey is chairman.

A large amount of time and effort has been spent during the year upon the organization of a new Subcommittee on Wool, of which Mr. G. E. Hopkins of the Bigelow-Sanford Carpet Co. has been appointed as chairman and it is the expectation that this subcommittee will be functioning in the fall. All important textile fibers will then be represented by subcommittees of Committee D-13.

Mr. A. E. Davieau has been appointed to serve as the temporary chairman of the Subcommittee on Knit Goods.

Mr. K. B. Cook has brought honor to the committee by his election in June 1931 to membership on the Executive Committee of the Society.

Those members of the committee who have accepted other opportunities for service, in addition to the work in which they are already engaged, are the following: Mr. W. M. Scott has represented the Society at several meetings of the Inter-Society Color Council, an organization of national societies and associations which is being formed for the purpose of collecting and disseminating scientific information about color, as well as promoting the standardization of color nomenclature and methods of specification. He has taken an active interest in this Council and has been elected a member of its Executive Committee. Mr. B. H. Foster is the representative of Committee D-13 on the General Membership Committee of the Society and has been active in bringing to the attention of the committee methods for securing new members. Mr. W. E. Emley accepted appointment as the representative of the committee on the newly formed Section on Calibration of Testing Machines and Apparatus under Committee E-1 on Methods of Testing.

Mr. W. H. Whitcomb has consented to serve as the publicity contact man for Committee D-13.

The records of attendance, subcommittee reports and work accomplished bespeak an active interest on the part of the members of Committee D-13 which is most encouraging. The officers of the committee take this opportunity to express their full appreciation of the voluntary service rendered by the chairmen and members of the subcommittees during the past year.

The present membership of the committee is 157, of whom 61 are classified as producers, 45 as consumers, and 51 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under Subcommittee Activities.

I. *Proposed New Tentative Standard.*—The committee recommends for publication as tentative proposed Tentative Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids, as appended hereto.[1]

II. *Proposed Tentative Revisions of Standards.*—The committee recommends that the revisions in the following standards be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 - 29), revised as given in the Appendix, item No. 1.

Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 27), revised as given in the Appendix, item No. 2.

III. *Proposed Revisions of Tentative Standard.*—The committee recommends that the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 31 T) be revised as given in full in the Appendix, item No. 3, and that the specifications as revised be continued as tentative.

IV. *Tentative Standards Continued as Tentative.*—The committee recommends that the following tentative standards be continued as tentative for another year without revision:

Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 - 27 T)[2];

Tentative Definitions of Terms Relating to Textile Materials (D 123 - 30 T);

Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 - 28 T);

Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content (D 232 - 25 T);

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[1] See p. 942.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1041 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 822.

Tentative Specifications for Tolerances and Test Methods for Silk and Cotton Tapes (D 259 - 31 T);

Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 - 31 T);

Tentative Specifications and Test Methods for Asbestos Tape for Electrical Puposes (D 315 - 31 T);

Tentative Specifications for Chafer Tire Fabrics (D 316 - 31 T);

Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating (D 334 - 31 T);

Tentative Specifications for 0.007-in. Cotton Tape (D 335 - 31 T);

Tentative Specifications for Enameling Duck for the Tire Industry (D 336 - 31 T);

Tentative Method of Determining Relative Humidity (D 337 - 31 T).

V. *Tentative Revisions of Existing Standards Continued as Tentative.*—The committee recommends that the tentative revisions in the following standards be continued as tentative for another year:

Standard General Methods of Testing Woven Textile Fabrics (D 39 - 27);

Standard Specifications for Textile Testing Machines (D 76 - 27);

Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 - 29).

The above recommendations have been submitted to letter ballot of the committee. The analysis of the vote of the committee is given in the following table:

Items	Affirmative	Negative	Not Voting
I. PROPOSED NEW TENTATIVE STANDARD			
Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids[a]	18	2	39
II. PROPOSED TENTATIVE REVISIONS OF STANDARDS			
Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 - 29)	31	1	34
Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 27)	26	1	32
III. PROPOSED REVISION OF TENTATIVE STANDARD			
Specifications for Tolerances and Test Methods for Rayon (D 258 - 31 T)	22	1	36

[a] The classified vote on the Tentative Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids was as follows: Affirmative: 7 producers, 6 consumers, 5 general interests; negative: 0 producers, 0 consumers, 2 general interests; not voting: 17 producers, 11 consumers, 11 general interests.

SUBCOMMITTEE ACTIVITIES

Subcommittee A-1 on Cotton (K. B. Cook, chairman):

Section I on Cotton (H. H. Willis, chairman).—This section on cotton has not been able to make as much progress as desired, since lack of funds made it impossible to obtain known samples of raw cotton on which to conduct tests on the three properties, (1) flexing resistance, (2) ability to stand repeated stress and (3) strength, as outlined in the 1931 report.

The section has done some work on variation in fibers and its relation to spinning utility, the results of which it hopes to report during the coming year.

Section II on Cotton Yarns and Threads (R. H. Adams, chairman).—This section is presenting for publication as tentative revisions in the present Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 27) (item No. 2, Appendix). The changes affect the specifications for the determination of satisfactory balance in a thread, and for securing the proper tension during reeling. More extensive use of the specifications indicated these changes were necessary to properly cover conditions arising with threads of any kind of finish.

The section has started to compile data on the strength of yarns for the purpose of revising the present standard yarn tables.

Section III on Light and Medium Cotton Woven Fabrics (R. T. Fisher, chairman).—This section has under consideration the development of a test method for determining shrinkage of certain light and medium woven cotton fabrics. It is expected that this will materialize into a tentative test method during the coming year.

Section IV on Tire Fabrics (B. H. Foster, chairman).—This section has decided to discontinue work on tentative specifications for breaker fabrics, mentioned in the last annual report. The prospect of standardizing these fabrics seems remote at present on account of the radical changes which are being made in their construction.

The section has been actively engaged in drawing up tentative specifications for No. 1 and No. 2 constructions of Holland cloth for use in the tire industry, and work upon these specifications is nearly completed.

Section VI on Narrow Fabrics (F. S. Mapes, chairman).—This section is presenting for publication proposed Tentative Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids, as appended hereto,[1] for which it feels there is a need.

In its study of methods for determining sizing content in cotton tapes, mentioned in the 1931 annual report, the section has assembled twelve different procedures. Inasmuch as this determination is of interest to other subcommittees, and in order to secure uniformity in methods, it has turned over the problem to Section I on Methods, of Subcommittee B-1 on Methods and Machines, for investigation.

The section has under consideration the need of specifications for automotive webbing and shoe tapes.

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[1] See p. 942.—ED.

Section VII on Osnaburg Cement Bags (W. D. Lober, chairman).—This section reports that there has been no change during the year in the general situation regarding cement bags. Lack of interest in osnaburg sacks is due to their extensive displacement by paper bags, the increasing trend toward cement shipments in bulk, and the decreased volume of total shipments.

Subcommittee A-2 on Rayon (A. M. Tenney, chairman):

Section I on Rayon (A. M. Tenney, chairman).—This section is presenting for publication revisions in the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 – 31 T) (item No. 3, Appendix). As a result of the changes, the intention to sample adequately a case of skeins is clarified, and the manner of drawing off the specimen for twist determination is specifically defined.

Section II on Rayon Fabrics (Alexis Sommaripa, chairman).—This section has under study and investigation at the present time a tension test method for wet specimens, a cloth fraying test, and a test for washability. These methods are being checked in the laboratories of the members. For future consideration, attention will be given to test methods to determine pulling at seams, slippage of fabrics, and oil and moisture content of oiled rayons.

Subcommittee A-3 on Wool (G. E. Hopkins, chairman).—The organization of this subcommittee has only just been completed. It has had no opportunity to function as yet, nor to lay out a program of work. This coming year should find it actively at work.

Subcommittee A-4 on Asbestos:

Section I on Asbestos Textiles (J. M. Weaver, chairman).—This section is presenting for publication as tentative revisions in the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 – 29) (item No. 1, Appendix). The title has been changed to read: Standard Specifications for Asbestos Yarns. The tolerances for the various grades of asbestos yarn have been changed so as to state the percentage of asbestos content instead of the cotton content. A new grade A-1, suitable for a number of products, has been added. The electric-furnace method of testing for percentage of asbestos has been substituted for the absorption method. The former method is more commonly used, is quicker and simpler, and permits the use of larger samples.

During the year this section presented revisions in Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 29 T). Important reductions were made in the tensile strength requirements to bring them into line with values which can be met more consistently. The construction requirements were changed by increasing the plus tolerance for both ends and picks per inch. This provides a needed leeway for those manufacturers and consumers who prefer a tape made with single ply yarn. The table of minimum requirements of yards per pound has been revised, and extended by the additions of six more sizes. These specifications, as revised, were submitted to Committee E-10 on Standards and accepted by it on behalf of the Society on August 6, 1931.[1]

At the present time the section is preparing specifications for asbestos roving. It is continuing its study of the determination and effect of magnetic iron in asbestos fiber and products. The section has been very active, and has shown a gain in membership and interest in its work.

Subcommittee A-5 on Jute, Ramie and Linen:

Section I on Sugar Bags (A. E. Davieau, chairman).—This section is recommending that the Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T) be continued as tentative for one year. This action seems advisable in view of the desire to effect economy in publication this year.

Subcommittee A-6 on Rope Fibers:

Section I on Rope and Cordage (J. S. McDaniel, chairman).—This section was represented by Mr. E. L. Lasier at a conference on the simplification of flax and hemp twine held in New York City on February 15, 1932, called by the Division of Simplified Practice of the U. S. Bureau of Standards.

Subcommittee A-7 on Silk (H. E. Bishop, chairman).—This newly organized subcommittee now consists of ten members. The program of work, which has resulted from its well attended meetings, includes studies of methods of examination and classification of broad silks, for determination of metallic weighting and water-soluble finishing materials, and for making twist and takeup tests.

Subcommittee B-1 on Methods and Machines (W. D. Appel, chairman):

Section I on Methods (W. D. Appel, chairman).—This section has continued its discussions which have for their object the elimination of unnecessary variations in similar test methods called for in the various specifications. A thorough revision of Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 31 T) is being undertaken. The section also has under consideration a study of tear tests and elongation tests of fabrics. It has also cooperated with Section III on Light and Medium Cotton Woven Fabrics of Subcommittee A-1 on Cotton in regard to shrinkage tests.

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[1] In submitting these specifications to Committee E-10 on Standards, the committee reported results of the letter ballot vote as follows: 67 members returned their ballots, of whom 23 voted affirmatively, 2 negatively and 42 refrained from voting.

Section II on Machines (H. J. Ball, chairman).—This section conducted some careful tests upon two types of bursting testers for the purpose of determining their relative uniformity. The test specimens were cut from identical fabrics, sixteen in number, covering a wide range of weights. The data secured were presented at a joint meeting with Subcommittee B-3 on Knit Goods, and by vote, was turned over to that subcommittee for consideration. The section is conducting an investigation of two types of attachments to twist testers for determining the twist in single yarns.

Section III on Humidity (G. B. Haven, chairman).—This section has been making many determinations from personal laboratory experiments regarding the regain of various fibers and fabrics at standard atmospheric conditions. It is hoped to present these figures as a tentative standard at a later date, when the experimental work can be more completely correlated. Any members having data of this type are invited to submit them to the subcommittee. It is highly desirable, after reasonable experimentation, that the standards of the Society should contain reference to correct and expected degrees of moisture in all textile materials.

Subcommittee B-2 on Nomenclature and Definitions (A. L. Brassell, chairman).—This section has been industriously at work upon the revision of the definitions of terms now appearing in the Standard Definitions of Terms Relating to Textile Materials (D 123 – 30) and in the Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T), as mentioned in the 1931 annual report. The work is now nearing completion, and a report is expected in the very near future.

Subcommittee B-3 on Knit Goods (A. E. Davieau, temporary chairman).—At the request of the Advisory Committee, Mr. A. E. Davieau has consented to serve as temporary chairman of this subcommittee until such time as it has disposed of the Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T). In this connection the subcommittee has under study and review the data on two types of bursting testers, submitted by Section II on Machines of Subcommittee B-1 on Methods and Machines.

Subcommittee B-4 on Bleaching, Dyeing, and Finishing (W. M. Scott, chairman).—This subcommittee is actively engaged in the development of standard methods for the analysis of small amounts of copper and manganese in textiles. Five methods for the determination of copper and four for the determination of manganese have been collected and subjected to critical examination. It is hoped that a standardized laboratory technique may be developed and presented as a tentative standard during the coming year.

The subcommittee is also collecting methods for the determination of sizing in textiles. It is planning to make a careful study of them with a view to the development of a satisfactory procedure which may be issued as a tentative standard.

Subcommittee on Papers (Dean Harvey, chairman).—It has been the practice of Committee D-13 to provide several papers on the subject of textile materials for the various meetings of the committee in order to acquaint the members with some of the work which is going on and also to furnish information regarding various textile products. This subcommittee has been responsible for securing three of those in the first list mentioned earlier in this report. It has made arrangements for all the papers presented at the session on textile materials to which reference has been previously made.

The following officers were elected for the two-year period from June, 1932, to June, 1934:

Chairman, H. J. Ball;
First Vice-Chairman, B. H. Foster;
Second Vice-Chairman, J. M. Weaver;
Secretary, W. H. Whitcomb.

This report has been submitted to letter ballot of the committee, which consists of 157 members; 48 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. BALL,
Chairman.

W. H. WHITCOMB,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Tolerances and Test Methods for Tubular Sleeving and Braids were accepted for publication as tentative and appear on page 942.

The proposed revisions of the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns and for Tolerances and Test Methods for Cotton Sewing Threads were accepted for publication as tentative and appear on pages 1005 and 1004, respectively.

The proposed revision of the Tentative Specifications for Tolerances and Test Methods for Rayon was accepted. The specifications in their revised form appear on page 934.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR TEXTILE MATERIALS

In this Appendix are given the proposed revisions of standards and tentative standards referred to in the body of this report, and which for ease of reference, are numbered 1 to 4, inclusive. Reference is also given to the publication in which each standard appears in its present form.

PROPOSED TENTATIVE REVISIONS OF STANDARDS

No. 1. *Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (D 299 - 29)*:[1]

Title.—Change the title of these specifications to read as follows by the omission of the words in brackets:

Standard Specifications for [Tolerances and Test Methods for] Asbestos Yarns.

Section 2.—Change Paragraphs (*a*) and (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

2. (a) Asbestos Yarn.—Asbestos yarn is yarn consisting of: (1) asbestos fiber, (2) asbestos and [cotton] *vegetable* fibers, or (3) asbestos and [cotton] *vegetable* fibers and wire.

(b) Plain Asbestos Yarn.—Plain asbestos yarn is yarn consisting of: (1) asbestos fiber, or (2) asbestos and [cotton] *vegetable* fibers.

Change Paragraph (*e*) to read as follows by the addition of the italicized word:

(e) Ply.—In the case of asbestos yarn, ply is the number of strands of single *asbestos* yarn twisted together to form a heavier yarn.

Section 5.—Add a new Grade A-1 of asbestos yarn to this section and change the present grades so as to specify the percentage of asbestos content instead of the cotton content, thus changing this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1099.

5. (a) The [cotton] *asbestos* content of both plain asbestos yarn and of metallic asbestos yarn shall conform to the following requirements:

Grade A-1	*77 per cent, minimum*
Grade A[a]	[15 to 20] *80 to 85* per cent
Grade AA	[8 to 10] *90 to 92* per cent
Grade AAA	[4 to 5] *95 to 96* per cent
Grade AAAA	[none] *100 per cent minus, tolerating a trace of foreign matter*

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[a] *Grade A meets Underwriters Laboratories' requirements.*

(b) The [cotton] *asbestos* content of metallic asbestos yarn shall be determined after all the wire has been removed from the test specimen.

Sections 6 and 7.—Replace the present absorption method for determining cotton content by the following electric-furnace method:

6. *Electric-Furnace Method.*—Dry a 1-oz. sample of asbestos yarn in a weighed crucible at 212° F. (100° C.) to constant weight. Ignite in an electric furnace at 1600° F. (871° C.) for 1 hour. Cool in a desiccator to room temperature and weigh. Divide the weight of ash by the factor 0.86[a] to determine original weight of asbestos fiber. To obtain the percentage of asbestos, divide the weight of asbestos by the weight of dried sample.

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[a] This factor is based upon a proved average of 14-per-cent water-of-crystallization in Chrysotile asbestos.

No. 2. *Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 27)*:[1]

Section 5.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

5. The finished sewing thread shall be balanced in twist as nearly as possible [and in no case shall a yard of thread when drawn from the side of a spool or package twist upon itself more than six times when brought together to form a loop] *to eliminate breakage from kinks during the sewing operation.*

Section 8.—Replace the second, third and fourth sentences of this section, which read as follows:

Any yarn reel having a 1½-yd. perimeter may be used in preparing the skeins. On reels that have only one pigtail guide, tension shall be applied by making one full wrap of the thread around the guide. On reels using two or more guides, the thread shall pass straight through the guides onto the reel, the angles of the guides supplying the necessary tension.

by the following sentence:

Any yarn reel having a 1½-yd. perimeter may be used in preparing the skeins, and tension shall be applied by making either two or three full wraps of the thread around the pigtail guide and reeled at a speed to lay the thread sufficiently taut on the reel.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1072.

PROPOSED REVISION OF TENTATIVE STANDARD

No. 3. *Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 31 T)*:[1]

Section 15.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

15. Two skeins of 200 turns each from each of 10 spools, cops, tubes, cones or [skeins] *skein bundles*, from one case out of every 10 cases shall be made, and the average of these 20 tests shall be the size or denier.

Twist.—Add the following new paragraph under Twist to be numbered Section 33, renumbering the present "Sections 33 to 35" as "Sections 34 to 36."

33. *Specimen.*—The specimen of yarn for twist determination shall be drawn from the side of the package instead of over the end in order to avoid changing the twist.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 974 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 796.

REPORT OF COMMITTEE D-18
ON
NATURAL BUILDING STONES

By reason of conditions that have existed during the past year, including several disorganizing factors, changes in personnel and the inability of the secretary as well as certain members of the committee to give the required time to the work, Committee D-18 was not able to make the hoped-for progress on its program during the past year.

During the year, three new members have been elected and two resignations have been accepted, leaving a total membership of 19, classified as 7 producer, 7 consumer and 5 general interest members.

Two new subcommittees have been organized during the year, namely, Subcommittee VI on Terms and Definitions and Subcommittee VII on Anchors and Anchorage Practice. The first of these subcommittees has already been appointed and action on the latter only temporarily deferred pending the qualifying of certain new members.

The committee believes that the following five tentative methods of testing and the definitions of terms relating to natural building stone should be advanced to standard:

Tentative Methods of:

Compression Testing of Natural Building Stone (D 326 – 30 T);
Flexure Testing of Natural Building Stone (D 327 – 31 T);
Test for Absorption and Apparent Specific Gravity of Natural Building Stone (D 328 – 31 T);
Test for Modulus of Elasticity of Natural Building Stone (D 338 – 31 T);
Shear Testing of Natural Building Stone (D 339 – 31 T).

Tentative Definitions of:

Terms Relating to Natural Building Stone (D 340 – 31 T).

These recommendations were submitted to letter ballot of the committee consisting of 18 members with the following results:

Item	Affirmative	Negative	Not Voting
ADVANCEMENT TO STANDARD OF TENTATIVE STANDARDS			
Tentative Method of Compression Testing of Natural Building Stone (D 326 - 30 T)	16	0	1
Tentative Method of Flexure Testing of Natural Building Stone (D 327 - 31 T)	15	0	2
Tentative Methods of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (D 328 - 31 T)	16	0	1
Tentative Method of Test for Modulus of Elasticity of Natural Building Stone (D 338 - 31 T)	15	0	2
Tentative Method of Shear Testing of Natural Building Stone (D 339 - 31 T)	15	0	2
Tentative Definitions of Terms Relating to Natural Building Stone (D 340 - 31 T)	16	0	1

In view of the desire of the Society to effect economy in publication this year, it would seem better to defer the advancement of these methods and definitions to standard until 1933, the year of issue of the Book of Standards.

Studies of the tension test and method of sampling have been completed by Subcommittee III and the committee accordingly plans to present these methods to the Society subsequent to the annual meeting through Committee E-10 on Standards, in the form of proposed Tentative Method of Tension Testing of Natural Building Stone and Method of Sampling Natural Building Stone and Sample for Testing.[1]

The proposed tentative methods were submitted to letter ballot of the committee which consists of 18 members: on the tension method 18 members returned their ballots, all of whom have voted affirmatively; on the sampling method 17 members returned their ballots all of whom have voted affirmatively.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Testing Procedure (H. S. Brightly, chairman). —This subcommittee has completed its studies of the tension test and method of sampling as mentioned earlier in the report. In view of the importance of the testing procedure section of the committee's program, the personnel of this subcommittee was enlarged last year in the hope that a thorough study of weathering, thermal and fatigue tests could be undertaken, but actual work on this part of the committee's program had to be deferred.

Subcommittee IV on Uniform Cubing of Stone (W. M. Greig, chairman).—This subcommittee is able to report very little progress in the development of the uniform cubing procedure for natural building stone. It hopes, however, to have the cubing procedure in final form very soon for submission to the committee as a tentative standard.

Subcommittee VI on Terms and Definitions (H. S. Brightly, chairman).—The second installment of terms and definitions applying to the work of Committee D-18 was prepared and distributed to the committee but the comments, criticisms and suggested changes or amplifications of certain of these definitions were such that this series of definitions could not be considered as satisfactory in their present form, making it advisable to have the proposed definitions reconsidered and given further study by this new subcommittee.

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[1] These methods were accepted for publication as tentative and appear on pp. 801 to 809. See Editorial Note, p. 497.—ED.

The committee wishes further to report that its secretary has accepted the chairmanship of Subcommittee XVI on Efflorescence and Staining of the newly formed Committee C-12 on Mortars for Unit Masonry and will also serve on that committee's Subcommittee on Specifications, as Committee D-18 by reason of its interest in the work of this new mortar committee intends to keep in close touch with its activities and collaborate actively in every way possible with the work of that committee.

The election of officers resulted in the selection of W. M. Greig, chairman, F. Y. Joannes, vice-chairman, and H. S. Brightly, secretary for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 18 members; 17 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

F. Y. JOANNES,
Chairman.

H. S. BRIGHTLY,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Sampling Natural Building Stone and Sample for Testing, and Method of Tension Testing of Natural Building Stone, referred to in the report, were subsequently accepted for publication as tentative on October 8, 1932, by Committee E-10 on Standards and appear on pages 801 and 807, respectively.

REPORT OF COMMITTEE E-1
ON
METHODS OF TESTING

Committee E-1 on Methods of Testing reports considerable activity on the part of several of its technical committees. The Technical Committee on Mechanical Testing has again been quite active through its various sections. As will be seen from the reports on the activities of these sections, as given in detail below, several new tentative standards and revisions in tentative standards are in prospect. It is expected that recommendations concerning these will be submitted to Committee E-10 on Standards so that the proposed tentative standards may be published during the year.

The Technical Committee on Presentation of Data, as mentioned elsewhere in this report, is continuing its program of round-table discussions so as to acquaint those interested with the possibilities of the newer theories concerning statistical analysis and with the methods of presenting test data.

Index to Methods of Testing.—A complete Index to the methods of test of the Society has again been issued in mimeographed form. This Index has proved of considerable assistance in the work of Committee E-1 in correlating the various methods as developed by the several standing committees, eliminating duplications of procedures where possible, and unifying the various descriptions of a given method of test. It also serves to keep the standing committees advised as to where the various procedures that have been prepared may be found, which is of considerable assistance when a standing committee has in mind the development of a new method of test.

Non-Destructive Testing.—Committee E-10 on Standards referred to Committee E-1 the question as to whether any work should be undertaken in the field of non-destructive testing. Various non-destructive tests are in use or have been proposed including the following: magnetic analysis, electrical resistance tests, X-ray examination, gamma-ray examination, hardness tests, stethoscope test, iron filings test, whiting test, etc. Of these, methods of magnetic analysis have received considerable study on the part of the Society's Committee A-8 on Magnetic Analysis. Committee E-4 on Metallography has developed methods of radiographic testing and proposes to extend this work to include gamma-ray methods. Committee E-1 has developed methods of hardness testing. In view of the work already under way in these several standing committees no new committee on non-destructive testing will be organized immediately, but if the need arises Committee E-1 may organize a coordinating committee which will work in cooperation with a committee on non-destructive tests functioning under the American Institute of Mining and Metallurgical Engineers.

At the last annual meeting of the Society, action was taken to place the Advisory Committee on a rotational basis so that the committee will consist of nine members, three members retiring each year. Mr. T. A. Boyd, Head, Fuel Section, Research Laboratories, General Motors Corporation, and Mr. R. L. Templin, Chief Engineer of Tests, Aluminum Company of America, were added to the committee to bring the total from seven members to nine as contemplated under the new procedure.

In response to a request received from the committees concerned, cooperation has been arranged between Committee D-2 on Petroleum Products and Lubricants and Committee D-9 on Electrical Insulating Materials in a review of the Tentative Methods of Neutralization Number of Petroleum Products and Lubricants (D 188 - 27 T) through the appointment of several representatives of each committee.

ACTIVITIES OF TECHNICAL COMMITTEES

Reports concerning the work during the year of the several technical committees are given below:

Technical Committee on Mechanical Testing (H. F. Moore chairman):

As is customary, the work of this technical committee has been carried on mainly through its various sections. The several proposed tentative standards and revisions of tentative standards referred to are expected to be recommended for publication as tentative in the near future through Committee E-10 on Standards.

The present organizational set-up of this technical committee has become rather unwieldly due to the formation of a large number of sections to give consideration to specific problems, and since all of the committees interested are represented on these individual sections the further review of the recommendations of these sections by a large representative technical committee seems unnecessary. Accordingly consideration is now being given to a plan of substituting for the complete technical committee a small advisory group composed of the chairman of the several sections, which advisory group will coordinate and supervise the work of the several sections.

Section on Tension Testing (R. L. Templin, chairman).—This section has prepared a proposed revision of the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 27 T) which is now being balloted upon in the technical committee for submission to Committee E-1. It is intended that these revised methods will be submitted to Committee E-10 on Standards so that they may be published in their revised form during the year.[1]

Section on Compression Testing (M. F. Sayre, chairman).—This section is giving consideration to several matters in connection with compression testing, as follows: (1) proper dimensions of specimen for compression test of metals, (2) position of spherical bearing block in compression tests of concrete and concrete masonry units and (3) development of methods of compression testing of non-metallic materials analogous to the present Tentative Methods of Compression Testing of Metallic Materials (E 9 - 27 T).

Section on Bend Tests for Ductility (A. B. Kinzel, chairman).—A subcommittee of the Section on Bend Tests for Ductility has continued checking the free bend test and its method of application. This has finally resulted in the publication of the Tentative Method of Bend Testing for Ductility of Metals (E 16 - 31 T)[2] which was accepted as tentative by Committee E-10 on Standards at a meeting held on August 6, 1931.[3] This method has also been accepted as part of the Unfired Pressure Vessel Code of the American Society of Mechanical Engineers.

In addition to the work on the free bend test, another subcommittee of this section has carried out a number of tests in connection with deep cupping. Some three hundred specimens were properly selected and submitted to eight cooperating laboratories for check and recheck Erichson and Olsen readings. Preliminary correlation of the results indicates an alarming lack of precision in the instruments, and this whole matter is being further investigated before any report will be submitted.

Section on Indentation Hardness (J. R. Townsend, chairman).—Proposed Tentative Methods of Rockwell Hardness Testing of Metallic Materials, prepared by this section, which were published as information with the 1931 report of Committee E-1,[4] are now being balloted upon by the technical committee for submission to Committee E-1. It is intended that these proposed methods will be submitted to Committee E-10 on Standards so that they may be published as tentative during the year.[1]

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[1] These methods were accepted for publication as tentative and appear on p. 945. See Editorial Note, p. 506.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1034 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 891.

[3] In submitting this method to Committee E-10, Committee E-1 reported results of the letter ballot vote as follows: 45 members returned their ballots, of whom 31 voted affirmatively, 1 negatively and 13 refrained from voting.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 595 (1931).

Section on Testing Thin Sheet Metals (C. H. Marshall, chairman).—The reorganized Section on Testing Thin Sheet Metals held a meeting in June, 1931, at which the work that had been done by this section was reviewed and it was recommended that the tentative standards for tension testing of thin sheet metals, which are now a part of the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 27 T), be advanced to standard.

The work of preparing specifications for standard methods of procedure for tension testing of thin sheet metals is now in progress. Other methods of testing sheet metals are also being considered at the present time.

Section on Impact Testing (W. W. Werring, chairman).—This section is endeavoring to learn by means of a questionnaire something of the extent to which notched-bar impact tests are used in practice and the practical significance of notched-bar impact values, based on the experience of metal users. Whether this section can function best as a section under Committee E-1 or as a research committee, is now under discussion by the section.

Section on Effect of Speed of Testing (P. G. McVetty, acting chairman).—The work of this section has been most seriously affected by the sudden death on April 12 of its chairman, Prof. J. Hammond Smith. Following the Proposed Requirements for Speed of Tension Testing of Metallic Materials, which were published as information with the 1931 report of Committee E-1,[2] a questionnaire requesting data on current practice in speed of testing was sent to 217 laboratories. The replies are summarized in the accompanying Table I. From the wide divergence in practice among the laboratories reporting it is evident that much work must be done to bring conflicting views into agreement before any attempt at standardization of testing speeds is possible. Such work is definitely under way and further investigation is planned for the future.

Section on Elastic Strength (F. B. Seely, chairman).—The Proposed Definitions of Terms Relating to Methods of Testing, including definitions for the terms "yield strength" and "elastic limit," which were published as information in the 1931 report of Committee E-1,[3] are now being balloted upon by the technical committee for submission to Committee E-1 to replace definitions of the terms "elastic limit," and "yield point" appearing in Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 30 T).[1] It is intended that the proposed definitions be submitted to Committee E-10 on Standards so that they may be published as tentative during the year.[2]

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[1] These methods were accepted for publication as tentative and appear on p. 961. See Editorial Note, p. 506.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 599 (1931).

[3] *Ibid.*, p. 602.

Attention is called to a paper being presented at this annual meeting by R. L. Templin on "An Automatic Autographic Extensometer for Use in Tension Tests of Materials,"[3] which presents a description of an apparatus that would facilitate the determination of the "yield strength" of materials.

TABLE I.—SUMMARY OF REPLIES TO QUESTIONNAIRE ON CURRENT PRACTICE IN SPEED OF TESTING.

Rate of Application of Load, lb. per sq. in. per minute[a]		Number of Tests Reported					
From	To	Steel	Wrought Iron	Cast Iron	Aluminum Alloys	Copper Alloys	Miscellaneous
....	1 000	..	..	..	..	..	3
1 000	5 000	1	1	..	6	..	9
5 000	10 000	10	2	..	4	5	5
10 000	20 000	29	4	..	..	5	..
20 000	30 000	26	1	15	6	3	..
30 000	40 000	55	10	1	5	5	..
40 000	50 000	33	7	..	16	8	..
50 000	60 000	31	4	..	10	5	..
60 000	70 000	38	1	..	10	3	..
70 000	80 000	17	..	..	3	4	..
80 000	90 000	16	..	..	..	6	..
90 000	100 000	16	3	..	..	3	..
100 000	110 000	21	..	..	3	1	..
110 000	120 000	14	1	..	..	..	..
120 000	130 000	9	1	..	..	2	..
130 000	140 000	..	1	..	..	1	..
140 000	150 000	2	..	..	..	..	..
150 000	160 000	1	..	..	..	..	..
160 000	170 000	1	2	..	..	..	..
170 000	180 000	1	1	..	..	..	..
180 000	190 000	..	..	..	..	1	..
190 000	200 000	5	..	..	..	..	..
200 000	500 000	4	3	..	..	..	..
500 000	1 000 000	6	1	..	..	..	..
1 000 000	1 500 000	5	..	..	..	..	..
Total Tests		341	47	16	63	52	17

[a] Values based on time measurement between two loads below the elastic limit.

Section on Calibration of Testing Machines and Apparatus (H. F. Moore, chairman).—This section has been organized with a membership composed of members from testing machine manufacturing firms and users of testing machines. The first meeting of this section is being held at the U. S. Bureau of Standards, Washington, D. C., with a subsequent meeting during this annual meeting of the Society.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1263 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 898.

[2] These definitions were accepted for publication as tentative and appear on p. 967. See Editorial Note, p. 506.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 783 (1932).

A paper of considerable interest to the Section on Calibration of Testing Machines is being presented at this annual meeting by H. F. Moore, J. C. Othus and G. N. Krouse on "Full-Load Calibration of a 600,000-lb. Testing Machine."[1]

Technical Committee on Consistency, Plasticity, Etc. (E. C. Bingham, chairman):

This technical committee is keeping in close touch with the work of the Society of Rheology at meetings of which society a number of papers are presented and discussed that have a direct bearing on the work of the technical committee. The committee is giving further consideration to the definitions of terms, which were published as information in the previous reports of Committee E-1, looking toward the possibility of submitting these definitions for publication as tentative at some future meeting.

Technical Committee on Size and Shape (L. T. Work, chairman):

This technical committee is faced with a situation somewhat similar to that referred to earlier in this report under the Technical Committee on Mechanical Testing. In this case also it is planned to organize a small advisory group to supervise the work of the several sections.

A Sectional Committee on Sieves for Testing Purposes has been organized during the year under the procedure of the American Standards Association with the Society and the U. S. Bureau of Standards as joint sponsors. This sectional committee will give consideration to specifications for sieves, using as a basis for discussion the Society's Standard Specifications for Sieves for Testing Purposes (E 11 – 26) and the Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 – 31 T). The personnel of the sectional committee includes practically all the members of the Section on Fine Sieves and in addition includes representatives of other interested organizations. In view of this interlocking personnel any recommendations concerning revisions of the present specifications will come up automatically for consideration in Committee E-1. Mr. L. T. Work and Mr. L. V. Judson have been elected chairman and secretary, respectively, of the sectional committee.

Section on Fine Sieves (A. A. Klein, chairman).—Mr. A. A. Klein, Petrographer with the Norton Co., has been designated chairman of the Section on Fine Sieves. Mr. Klein's work on perforated plate of small apertures and his general knowledge of the exact sieving problems of the abrasive industry make his selection a very happy one. The section has before it the consideration of methods of conducting fineness tests and methods of reporting results.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 778 (1932).

Section on Sub-Sieve Sizes (G. S. Haslam, chairman).—The status of the work of this section is essentially the same as it was at the time of the last report. It is the feeling of the section that the next step is to arrange for a centralized investigation at some university. The financial support for such an investigation is not forthcoming at the present time although the interest shown by the various industries concerned justifies the belief that under more favorable industrial conditions such a program could be carried out successfully. The committee is not as yet prepared to recommend for publication as tentative the Proposed Method of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances, which was published as information with the 1930 report of Committee E-1.[1]

Section on Coarse Screens (F. H. Jackson, chairman).—The Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 – 31 T),[2] presented as information with the 1931 report of the committee, were accepted for publication as tentative by Committee E-10 on Standards at a meeting held on August 6, 1931.[3] These specifications have been brought to the attention of the interested committees together with the proposal that agreement be reached on the use of either square-mesh screens or round-hole screens in the classification by size of such materials as crushed stone, gravel, blast-furnace slag, etc. This proposal is still before the standing committees for consideration.

Technical Committee on Chemical Composition (G. E. F. Lundell, chairman):

Reorganization of this committee is now in process, looking toward the appointment of a small advisory group of expert analysts serving with the representatives of the several standing committees interested. This form of organization has proved particularly effective in the case of other technical committees.

Technical Committee on Thickness Measurement (W. E. Emley, chairman):

While the Technical Committee on Thickness Measurement has not held a meeting during the year, it nevertheless has been active, as may be seen from the following:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 919 (1930).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1032 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 870.

[3] In submitting these specifications to Committee E-10, Committee E-1 reported results of the letter ballot vote as follows: 45 members returned their ballots, of whom 35 voted affirmatively, none negatively and 10 refrained from voting.

Committee D-9 on Electrical Insulating Materials has adopted a rachet micrometer for measuring the thickness of condenser paper after an elaborate series of experiments which demonstrated that measurements made with the instrument check each other with sufficient precision. The committee's attention was called to the inadvisability of requiring a special type of gage for condenser paper. Under present specifications, it could not be used for any kind of paper other than condenser, nor for any kind of insulating material other than paper.

The attention of Committee D-11 on Rubber Products and the Rubber Products Committee of the Federal Specifications Board has been called to the confusion resulting from their requirements for different gages for measuring the thickness of rubber. The gages are exactly alike except that the former committee requires a load of 8 to 10 oz.; the latter, 3 oz.

The attention of Committee D-13 on Textile Materials was called to the fact that in a proposed new specification for tubular sleeving, the thickness requirements were given in thousandths of an inch and thickness was to be measured by means of a gage with uncontrolled pressure. Since the material is quite compressible, the committee must either adopt a different type of gage or be content with a lower degree of precision.

The Bureau of Standards has now in operation three gages which are entirely different in both principle and construction from each other and from anything now on the market. Experiments with these gages are being watched, and in one case the results are being checked against the thickness as computed from density measurements.

An article on thickness measurements setting forth the views of the chairman of this technical committee was published in the *Commercial Standards Monthly* for March, 1932.

Technical Committee on Presentation of Data (W. A. Shewhart, chairman):

This technical committee has had a very active program committee at work during the year under the chairmanship of Mr. Anson Hayes. This program committee has arranged for a round-table discussion on "Acquisition of Good Data" to be held on Monday evening and Tuesday morning during the present annual meeting of the Society. The list of informal papers being presented to lead the discussion is as follows:

"Statistical Nature of A.S.T.M. Data," by R. F. Passano;
"Specifications of Standards of Quality," by N. F. Harriman;
"Inspection Specifications," by G. D. Edwards;

"Need for Control in Sampling Inspection," by H. F. Dodge;
"Criteria for Rejection of Observations," by P. R. Rider;
"Methods of Dealing with Discordant Observations," by E. W. Washburn;
"Elimination of Systematic Errors," by H. C. Dickinson;
"Rôle of Statistical Method in Economic Industrial Standardization," by W. A. Shewhart.

In addition to these, mention should be made of two formal papers that are being presented at technical sessions of the annual meeting, namely, "Controlled Data from an Immersion Test," by R. F. Passano,[1] and "Application of Control Analysis to the Quality of Varnished Cambric Tape," by M. F. Skinker.[2]

The Advisory Committee of Committee E-1 has asked the Technical Committee on Presentation of Data to prepare recommendations concerning the form of presenting test results that could be embodied in instructions to prospective authors of papers to be presented before the Society. Such instructions should be of considerable assistance in ensuring the better presentation of data in the papers and in enhancing the facility with which such data could be analyzed.

The election of officers for the ensuing term of two years resulted in the reelection of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 57 members; 42 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Rockwell Hardness Testing of Metallic Materials, referred to in the report, were subsequently accepted for publication as tentative on August 11, 1932, by Committee E-10 on Standards and appear on page 961.

The proposed revisions of the Tentative Methods of Tension Testing of Metallic Materials and of the Tentative Definitions of Terms Relating to Methods of Testing, also referred to in the report, were subsequently accepted on August 11, 1932, by Committee E-10 on Standards. The methods and definitions in their revised form appear on pages 945 and 967, respectively.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 468 (1932).

[2] *Ibid.*, p. 670.

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

During the year, Committee E-4 on Metallography held three meetings, the first in Chicago, Ill., on June 26, 1931; the second in New York City on February 18, 1932; and the third in Cleveland, Ohio, on March 8, 1932.

During the year membership changes occurred as follows: Mr. Leon Foster has been appointed by the Bausch & Lomb Optical Co. to serve as representative in place of Mr. W. L. Patterson, deceased; Mr. L. L. Wyman has been appointed by the General Electric Co. to serve as representative in place of Mr. W. E. Ruder; Mr. C. H. Bierbaum has resigned; and Mr. J. T. Norton, Massachusetts Institute of Technology, has been elected to membership.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Selection and Preparation of Samples (E. H. Dix, Jr., chairman).—This subcommittee held a special meeting in Cleveland, Ohio, on March 8, and reported considerable progress on the revision of the Standard Methods of Metallographic Testing of Iron and Steel (E 3 – 24) and of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 27). It was decided that these two methods should be rewritten and combined into a single method of metallographic testing covering the general procedure common to both ferrous and non-ferrous metals and alloys, with separate sections dealing with the special methods for each of these different types of alloys.

The subcommittee has reviewed the paper by W. H. Bassett, Jr. and C. J. Snyder on "Method of Preparation of Lead and Lead Alloy Cable Sheath for Microscopic Examination" to be presented at this annual meeting.[1] A paper by another member, Mr. Samuel Epstein, entitled "A Suggested Method for Determining the Cleanness of a Heat of Steel" has been sent to all members of Committee E-4, and a recommendation made that this subject be given consideration.

Subcommittee III on Thermal Analysis (Howard Scott, chairman).—It was voted at the meeting in New York City that Committee E-4 recommend for advancement to standard the Tentative Recommended Practice for Thermal Analysis of Steel (E 14 – 30 T).

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 558 (1932).

However, upon reconsideration and from the standpoint of publication economy, it would seem better to defer adoption as standard until 1933, when the next edition of the Book of Standards will be issued.

Subcommittee IV on Photography (H. S. Rawdon, chairman).—Five laboratories, including three members of the subcommittee, have cooperated with the subcommittee in trying out the following recommended list of lens combinations which was submitted at the June, 1931, meeting:

MAGNIFICATION	OBJECTIVE	OCULAR
25X	48 or 42 mm.	5X
50X	32 mm.	5, 6, or 7.5X
100X	16 mm.	5, 6, or 7.5X
250X[a]	8 mm.	5, 6, or 7.5X
500X	4 mm.	5, 6, or 7.5X

[a] This magnification was approved in 1931 by letter ballot of the committee.[1]

Specimens employed in this work included duralumin, brass and lead cable sheath (for very low magnifications); also steel having low, medium (sorbitic pearlite), and eutectoid (lamellar pearlite) carbon content. The results affirm the suitability of the recommended list of lens combinations for the magnifications in question. The above table constitutes a proposed revision of the Recommended Practice for Photography as Applied to Metallography, appearing in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 – 30). Since no definite action has been taken by the subcommittee on other proposed changes, the whole suggested revision will be taken up at the next annual meeting.

Subcommittee VI on X-ray Methods (L. W. McKeehan, chairman).—This subcommittee has been further strengthened by additions to its membership, and has kept in touch with recent advances in X-ray and gamma-ray testing.

Special Subcommittee on Grain Characteristics of Steel (C. J. Tobin, chairman).—After a number of meetings and conferences, this subcommittee has decided on a system of classification of S.A.E. and allied steels with respect to grain size. The plan as outlined by Mr. Tobin would involve carburizing samples of the steel under investigation at 1700° F. for not less than 8 hours in a compound which will produce a hyper-eutectoid zone and cooling slowly enough to produce a pearlitic structure in the case. Classification of specimens thus treated with respect to grain size will be accomplished by comparison of the hyper- and hypo-eutectoid zones at a magnification of 100 diameters with those of a standard chart which they propose to prepare. This standard chart will show micrographs of both hyper- and hypo-eutectoid zones of eight different ranges of grain size. Preliminary work by this group of the special subcommittee has been done by representatives of producers and consumers and is believed to be acceptable to both parties.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 612 (1931).

In accordance with a decision at the Cleveland meeting, the report of this Special Subcommittee on Grain Characteristics of Steel, when finished, will be submitted to Committee E-4 for approval by letter ballot.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 52 members; 41 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. DAVIS,
Chairman.

O. E. HARDER,
Secretary.

REPORT OF COMMITTEE E-6
ON
PAPERS AND PUBLICATIONS

The activities of Committee E-6 comprise the supervision of all publication matters including the development of the technical program for the annual meeting and the review of papers prior to their acceptance.

Program of 1932 Annual Meeting:

Probably the outstanding feature of the program for this meeting is the Symposium on Steel Castings. This is the second of several that have been planned by the American Foundrymen's Association and our Society for the purpose of providing the engineering profession with authoritative data on the properties of castings. The Steel Castings Symposium has been in charge of the following committee:

W. C. Hamilton, *chairman*
W. M. Barr
George Batty
R. A. Bull
J. A. Capp
Fred Grotts
R. E. Kennedy
J. H. Locke
Steel Founders Society
Jerome Strauss
C. L. Warwick
G. B. Waterhouse

The Papers Committee wishes to express its appreciation of the services rendered by this committee in developing the program and in reviewing the papers. The publication of the symposium is being undertaken jointly by the A.F.A. and the A.S.T.M.

In 1933 it is planned to cover in this way the subject of cast iron to be followed in subsequent years by discussions of castings of various non-ferrous metals and alloys.

The Society's Committee D-13 on Textile Materials has sponsored a very interesting session on textiles which includes a number of valuable and instructive papers in this field.

In addition to these features the program contains reports from nearly all of the standing and research committees and from several sectional committees functioning under A.S.A. procedure with the A.S.T.M. as sponsor. The total number of reports on the program is 49.

The technical papers on the program, in addition to those already mentioned in connection with the several symposiums, cover many of the materials fields in which the Society is engaged, including cement and concrete, corrosion and fatigue of metals, iron and steel, magnetics, and testing. The technical program also provides for a round-table discussion on acquisition of good data to which two sessions have been assigned. The total number of papers is 45, making 94 items on the program.

While it has not been possible to preprint everything for the meeting due partly to budget limitations and partly to the fact that some few reports and papers were received so late as not to leave adequate time for editing and publication, all but 12 reports and papers have been printed.

As usual the preprints were distributed to the members in advance of the meeting in two installments and a third installment is being distributed during the week of the meeting. The following table gives statistical information on preprinting:

	REPORTS		PAPERS		TOTAL	
	NUMBER	PAGES	NUMBER	PAGES	NUMBER	PAGES
Preprinted	43	657	39	462	82	1119
Not preprinted	6	104[a]	6	203	12	307
	49	761	45	665	94	1426

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[a] Includes approximately 80 pages of material temporarily omitted from preprinted reports.

Papers for Cleveland Regional Meeting:

The papers for the third Regional Meeting of the Society held March 9, 1932, at Cleveland, constituted a Symposium on Rubber planned jointly by the Cleveland District Committee and the Committee on Papers and Publications. The titles and authors of the twelve papers comprising the symposium are given below:

The Extent and Diversity of the Rubber Industry—Arthur W. Carpenter.
Crude and Reclaimed Rubber—R. H. Gerke.
Vulcanization—N. A. Shepard.
Compounding: A Discussion of the Fillers, Reinforcing Agents and Softeners Used in the Compounding of Rubber—R. H. Seeds.
Structures of Rubber in Combination with Textiles and Other Materials—C. H. Zieme.
The Flexing of Rubber Products—E. G. Kimmich.
Shock and Vibration Properties of Rubber in the Automobile—W. J. McCortney.
Some Factors in the Deterioration of Rubber when Exposed to Frictional Contacts with Other Materials—V. A. Cosler.
The Chemical Resistance of Rubber as an Engineering Material—H. E. Fritz and J. R. Hoover.
Resistance of Rubber to Water and Gases—R. H. Gerke.
Electrical Characteristics of Rubber Insulation—E. W. Davis and G. J. Crowdes.
Rubber as an Adhesive—J. J. Allen and J. E. Beyer.

Of these twelve papers eleven were printed in advance. All the papers with discussion will be reprinted in a single pamphlet and furnished to members at special prices.

Selected A.S.T.M. Standards for Students:

The second edition of "Selected A.S.T.M. Standards for Students in Engineering" (3500 copies) was published in the fall of 1931, the two printings of the first edition having been completely sold to students in engineering in technical schools. A study of the use of this pamphlet in these schools indicated a need for a selection of standards that would be of more direct value to students in chemistry, chemical engineering, and metallurgy, and accordingly a selection of such standards was published in December, 1931, the edition being 1250 copies. While the first pamphlet seems to have become quite well established in many of the engineering schools, it is expected that some little time will be required to put the second pamphlet on a comparable basis. Notwithstanding, the use of these pamphlets during the college term just closing has been reasonably satisfactory.

Proposed A.S.T.M. Journal:

The Executive Committee has deemed it desirable to have a study made of the possibility of publishing a journal of the Society in view of proposals that have been advanced on various occasions that the present Bulletin might be expanded into a technical journal. Committee E-6 was accordingly directed to make a thorough study of the matter, giving the fullest consideration to the relationship of such a journal with the present procedure in the publication of reports and papers and in the development and publication of standards. This study is now under way.

Regular Publications:

The regular publication activities carried on during the year are referred to in the annual report of the Executive Committee based upon information supplied by the Papers and Publications Committee.

In addition, the Papers and Publications Committee publishes new tentative standards submitted by the standing committees between annual meetings and approved by Committee E-10. In the past year 19 such standards were thus published, the titles being given in the report of Committee E-10. Of these all but two appeared in the *Proceedings* and in the Book of Tentative Standards for 1931. These two, namely, the Specifications and Tests for Masonry Cement and the Tentative Standard Viscosity-Temperature Chart for Liquid

Petroleum Products were printed early in 1932 and published in separate pamphlet form. The last named of these two tentative standards involved the preparation of a chart for plotting viscosity data that required extreme accuracy in its preparation. The chart, which is approximately 16¼ by 21½ in. has been published on thin paper bound in pads of 25, and also on heavy Bristol board. A total of approximately 22,000 such sheets has so far been printed.

Papers Presented at District Meetings:

The following papers have been presented at meetings sponsored by the several district committees of the Society:

New York District Committee Meeting—November 5, 1931:

The History of Protective Coatings—Maximilian Toch
The Economics of Paint—H. A. Gardner
Failure of Non-Metallic Coatings—James K. Hunt

New York District Committee Meeting—February 18, 1932:

Limitations of Our Fundamental Knowledge of the Properties of Metals—F. O. Clements
Test Results and Service Values of Materials—H. F. Moore

Detroit District Committee Meeting—March 28, 1932:

Road Testing of the Entire Automobile—A. J. Schamehorn
Destructive Testing of Automotive Products—J. M. Watson
Service Complaints on Automobiles as Related to Engineering Tests—Nicholas Dreystadt
Relation of Service Testing to Metallurgy of Automobile Parts—J. L. McCloud
Service Tests of Automobile Fuels and Lubricants—D. P. Barnard
Service Testing of Automobile Tires—S. M. Cadwell

Chicago District Committee Meeting—April 11, 1932:

Relation of Tested Material to Safe and Economic Engineering—H. F. Moore

New York District Committee Meeting—April 28, 1932:

Material Problems in the Production of Petroleum—E. A. Estabrook
Modern Material Problems in the Refining of Petroleum—A. E. Pew, Jr.

Papers Presented at Committee Meetings:

The following papers have been reported to the Papers Committee as having been presented at the meetings of Committee D-13 on Textile Materials:

The Value of Specifications to Industry—D. B. Wainwright, Jr.
Thickness Measurements—W. E. Emley
Control of Humidity in Small Enclosed Spaces—F. T. Carson
Most Textile Secrets are "Undiscovered" Knowledge—C. H. Clark

Investigation of Methods for Conditioning Rayon Fabrics for Wet Tensile Strength Test—Alexis Sommaripa.

Testing Knit Goods—G. B. Haven.

Some Factors Influencing the Spinning Quality of Cotton—H. H. Willis

Plans for 1933 Annual Meeting:

Plans are already under way for the technical program of the 1933 annual meeting. In addition to the Symposium on Cast Iron mentioned previously, Committee C-9 on Concrete and Concrete Aggregates has arranged for a Symposium on Significance of Tests of Concrete and Concrete Aggregates. The authors have already been selected and are at work on the preparation of the individual papers so that opportunity will be afforded to review these during the year in order to unify the several sections and to present the discussion in a concise form. Other symposiums and topical discussions are also in prospect.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS

Relatively few definitions have come up for action in Committee E-8 during the past year. Accordingly no meetings of the committee have been held other than the meeting held during the 1931 annual meeting of the Society in Chicago, Ill. Several of the subcommittees, however, have been quite active, notably the Subcommittee on Definition of Coke, under the chairmanship of Mr. H. C. Porter, which committee has been endeavoring to unify the views of Committees D-5 on Coal and Coke and D-2 on Petroleum Products and Lubricants in the development of a satisfactory definition for the term coke. A report of this subcommittee will come up for consideration at a meeting of Committee E-8 to be held during the approaching annual meeting of the Society.

Similarly the Subcommittee on Definition of Net and Gross Calorific Values, also under the chairmanship of Mr. Porter, has been active in stimulating an exchange of views of those interested in these definitions. Definitions for these terms are of interest in international discussions now taking place having to do with the assembling of data on fuel resources.

Of the definitions now published as tentative, a group relating to road materials is being recommended for adoption as standard at this annual meeting. These definitions were developed through the cooperation of Committees D-2 on Petroleum Products and Lubricants, D-4 on Road and Paving Materials and D-8 on Bituminous Waterproofing and Roofing Materials in connection with international discussions on definitions of terms relating to road materials instituted by the International Road Congress. The definitions have been approved by the Subcommittee on Definitions Relating to Bituminous Materials, under the chairmanship of Mr. K. G. Mackenzie, and on the authorization of the Advisory Committee they are now out to letter ballot in Committee E-8.

The fact that so few definitions have come up for consideration in Committee E-8 during the year is not to be construed as an indication of any limited interest in the development of definitions nor a lack of appreciation of their importance and significance. It is known that a number of standing committees are now at work in the development of definitions of terms as, for example, Committee D-13 on Textile

Materials which has a very extensive list under consideration, Committee C-9 on Concrete and Concrete Aggregates, Committee D-1 on Preservative Coatings for Structural Materials, Committee D-10 on Shipping Containers and Committee D-18 on Natural Building Stones. Mention should also be made of the development of definitions in certain subcommittees of Committee E-1 on Methods of Testing, notably in the Section on Elastic Strength of Materials, which is preparing to recommend for publication as tentative a definition for "yield strength" which may supersede such definitions as "yield point," etc. Proposals have also come to the attention of Committee E-8 that subcommittees be organized on definitions of terms relating to heat transmission, and on definitions of terms of interest to the non-ferrous metals industry.

Glossary of Terms.—The Glossary of all terms appearing in the standards and tentative standards of the Society was again issued during the year in mimeographed form and was brought to the attention of all members of Committee E-8 and the officers of standing committees. It has further received wide distribution as a result of an announcement appearing in the A.S.T.M. BULLETIN that copies were available to all those interested.

In preparing new definitions the standing committees should, of course, consult the Glossary to see if the terms which it is proposed to define are already included therein.

During the year action was taken to place the Advisory Committee on a rotational basis so that the committee will consist of six members, two members retiring each year.

The committee suffered a severe loss during the year in the death of Mr. Hugh P. Tiemann, a member of the Advisory Committee. Mr. Tiemann served long and faithfully on the committee and contributed greatly to the work in his capacity as a member of the Editorial Committee. His interest and experience in precise thinking and expression were invaluable in the work of the committee.

Definitions Approved by Committee E-8.—Two terms were approved at the 1931 annual meeting, namely, the definitions for the terms "spalling" and "pyrometric cone equivalent," which bring the total of standard definitions approved to 259.

DEFINITIONS RECOMMENDED FOR ADOPTION AS STANDARD

As mentioned earlier in this report, five definitions that have been approved by Committee E-8 are being recommended for adoption as standard at this annual meeting, namely, the definitions for the terms "bitumens," "asphalts," "fluxes," "tars," and "pitches," under the jurisdiction of Committee D-4 on Road and Paving Materials. The definitions in the form in which they are being recommended for adoption were published a year ago as tentative revisions[1] of the definitions of these terms appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18).[2]

The definitions recommended for advancement to standard have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
ADVANCEMENT TO STANDARD OF TENTATIVE DEFINITIONS			
1. Definition for the Term "Bitumens"	11	2	7
2. Definition for the Term "Asphalts"	11	2	7
3. Definition for the Term "Fluxes"	11	2	7
4. Definition for the Term "Tars"	11	2	7
5. Definition for the Term "Pitches"	11	2	7

TENTATIVE DEFINITIONS BEFORE COMMITTEE E-8

Thirty-seven new tentative definitions were submitted at the 1931 annual meeting, as follows:

Terms Relating to Gypsum:

- Gypsum Concrete
- Gypsum Fiber Concrete
- Gypsum Lath
- Gypsum Sheathing Board

Terms Relating to Textile Materials:

- Absolute Humidity
- Relative Humidity
- Dew Point
- Vapor Pressure
- Dry Bulb Temperature
- Wet Bulb Temperature
- Hygrometer
- Absorption Hygrometer
- Wet and Dry Bulb Hygrometer or Psychrometer
- Recording Hygrometer or Psychrometer
- Sling Psychrometer

Terms Relating to Natural Building Stone:

- Stone
- Building Stone
- Granite
- Building Granite
- Basalt
- Limestone
- Building Limestone
- Oolitic Limestone
- Dolomite
- Marble
- Building Marble
- Decorative Marble
- Dolomite Marble
- Sandstone
- Quartzite
- Building Sandstone
- Building Slate or Argillite
- Igneous Rock
- Volcanic Rock
- Sedimentary Rock
- Metamorphic Rock
- Trap Rock

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 1069 (1931); also 1931 Book of A.S.T.M. Tentative Standards, p. 935.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 673.

These definitions will receive the attention of the Editorial Committee during the coming year and comments concerning them will be brought to the attention of the standing committees concerned.

This report has been submitted to letter ballot of the committee, which consists of 46 members; 33 members returned their ballots, of whom 31 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

REPORT OF COMMITTEE E-9
ON
RESEARCH

The Committee on Research presents in this its eighth annual report a brief review of the status of some of the important research projects which are being carried on under the auspices of the Society. A more comprehensive review will appear in the A.S.T.M. Bulletin this coming October.

Research Committee Activities:

The Research Committee on Effect of Tin and Arsenic on High-Speed Tool Steels has made no progress in consideration of this subject since its report to the Society in 1929,[1] due largely to the recent development of methods of freeing tungsten from arsenic and tin, so that the problem no longer has the commercial significance that led to the institution of the project originally. Accordingly, Committee E-9 has recommended to the committee that it prepare a final report of its activities and request its discharge.

The Research Committee on Yield Point of Structural Steel has started a series of tests to determine the effect of aging on the yield point of structural steel.

The Research Committee on Fatigue of Metals is presenting to the Society at this meeting supplementary chapters to their 1930 report on Present-Day Knowledge of Fatigue of Metals.

The Joint Committee on Effect of Phosphorus and Sulfur in Steel is carrying on further tests at Watertown Arsenal to determine the effect of sulfur on forging steels. This committee has recently completed tests made at the Naval Engineering Experiment Station to determine the effect of added phosphorus in low-carbon (pipe) steel, which are now being studied for report to the sponsor societies.

The A.S.M.E.-A.S.T.M. Joint Committee on Effect of Temperature on the Properties of Metals is carrying on experimental work on the high-temperature creep properties of nickel-chromium austenitic steels at Battelle Memorial Institute, and tests on the fatigue strength of the same steels at elevated temperatures are being made at the University of Illinois. These projects are being supported by funds contributed by various industrial and research groups to the two sponsor societies. The Joint Committee is presenting a report at this meeting dealing with a number of studies made during the past year or two. At the instance of Committee A-2 on Wrought Iron, consideration is being given to initiating a project to study the high-temperature properties of wrought iron used in manufacture of pipe.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 167 (1929).

The Joint Committee on Correlation of Research in Mineral Aggregates, functioning under the auspices of the Highway Research Board, National Research Council, is progressing satisfactorily with its studies of these materials. The following papers on this subject were presented at the annual meeting of the Highway Research Board in December, 1931:

"Shales in Aggregates," by E. E. Bean.[1]

"Significance of Freezing and Thawing and Sodium Sulfate Tests of Mineral Aggregates," by Verne McCown.[2]

"A Discussion of Necessary Aggregates for Road-Mixed Surfaces," by C. N. Conner.

New Research Projects by Standing Committees:

The following new major research projects were reported in the review of Society research activities published in the A.S.T.M. BULLETIN for October, 1931:

Corrosion Tests of Electroplated Coatings (Committee A-5 on Corrosion of Iron and Steel);

Investigation of Tin- and Lead-Base Die-Casting Alloys (Committee B-6 on Die-Cast Metals and Alloys);

Permeability of Concrete (Committee C-9 on Concrete and Concrete Aggregates).

The importance of further research in the field of light alloys has been called to the attention of the committee, and also the importance of making readily available the results of the quite considerable work which has already been done. The committee has brought this matter to the attention of Committee B-7 on Light Metals and Alloys, Cast and Wrought, which committee has appointed a subcommittee with authority to develop such projects as it deems desirable and finds feasible. Plans are being made for an interesting report on this subject at the annual meeting in 1933.

Research projects initiated by the committees since the 1931 annual meeting will be announced in the "Review of A.S.T.M. Research Activities, 1932" to be published in the A.S.T.M. BULLETIN next October.

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[1] *Pit and Quarry*, April 20, 1932, p. 46.

[2] *Eleventh Annual Proceedings*, Highway Research Board, National Research Council, Vol. 11, Part I, p. 312 (1932).

The committee again calls to the attention of committees of the Society the desirability of periodic summaries of knowledge in the particular field covered by each committee.

Miscellaneous Administrative Matters:

The term of George K. Burgess expired in June, 1931, and H. W. Gillett was appointed to membership in his place.

The term of F. E. Schmitt expires at the close of the 1932 annual meeting; the appointment of his successor will be made by the Executive Committee of the Society.

The present officers were re-elected for the ensuing term of two years.

The principal of the A.S.T.M. Research Fund is $8387.85. The balance of income reported a year ago as of June 15, 1931, was $277.32. Receipts since then have totalled $360, representing interest on investments. There have been no disbursements during the year, and the balance as of May 31, 1932, is therefore $637.32.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

REPORT OF COMMITTEE E-10
ON
STANDARDS

Committee E-10 on Standards held one meeting during the year, in Philadelphia, Pa., on August 6, 1931. A number of standing committees have taken advantage of the procedure for submitting to the Society in the interval between annual meetings new tentative standards or revisions of tentative standards whereby these are reviewed by Committee E-10 and accepted for publication during the year. This procedure has now become well established as a means of expediting the standardization work of the Society. A number of projects came up for consideration resulting in steps being taken looking toward the organization of new standing committees. The committee has been in responsible charge of the submission of A.S.T.M. standards to the American Standards Association for approval as American Standard or American Tentative Standard.

The activities of the committee during the year are set forth in this report under the following heads: review of A.S.T.M. standardization activities, consideration of new and revised tentative standards, relations with American Standards Association, and promotion and expansion of standardization activities.

Review of A.S.T.M. Standardization Activities:

A general summary of the new tentative standards submitted at the 1931 annual meeting, of tentative standards advanced to standard and of revisions in standards was included in the July issue of the A.S.T.M. BULLETIN, together with a review of the standardization work of the various committees with statements concerning new standards in prospect. Much of the information, particularly in respect to standardization projects in development in committees, is furnished by the standing committees subsequent to the annual meeting and takes advantage of the fact that many committees plan their next year's work at committee meetings held during the annual meeting.

At the present writing it is possible to make only an approximate estimate in terms of new and revised standards of the volume of standardization work accomplished during the year and reported to the Society at this meeting. The reports of standing committees to be presented at the annual meeting include recommendations to the Society substantially as follows:

New tentative standards	41
Tentative revisions of existing standards	44
Revisions of tentative standards	30
Tentative standards recommended for advancement to standard	2
Revisions of existing standards recommended for adoption as standard	9
Standards and tentative standards withdrawn	5

There are at present 443 standards and 182 tentative standards of the Society making a total of 625, and if the above recommendations are approved this total will become 661.

Consideration of New and Revised Tentative Standards:

A number of new tentative standards and revisions of existing tentative standards were submitted to Committee E-10 during the year under the procedure providing for such submission in the interval between annual meetings. Committee E-10 on receiving such recommendations from the standing committees reviews them principally to insure that a substantial consensus has been reached in the standing committee concerned. It requires that the complete vote be recorded, analyzed according to producers, consumers, and general interests. If there are any negative votes the names of those voting in the negative must be recorded together with the reasons for so voting. A report from the standing committee is required giving the usual information, setting forth the needs for having the standard, that is, whatever demand may have prompted the committee in preparing it and also on what material the standard is based, that is, whether it is based upon standards already in existence or on work carried out by the committee, etc.

Proposed new standards that were approved by Committee E-10 and published as tentative during the year are as follows:

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (A 134 - 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 - 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications for Forge-Welded Steel Pipe (A 136 - 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications for Lock-Bar Steel Pipe (A 137 - 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 - 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications and Tests for Masonry Cement (C 91 - 32 T), submitted by Committee C-1 on Cement;

Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (C 88 – 31 T), submitted by Committee C-9 on Concrete and Concrete Aggregates;

Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (C 89 – 31 T), submitted by Committee C-9 on Concrete and Concrete Aggregates;

Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 – 31 T), submitted by Committee C-10 on Hollow Masonry Building Units;

Tentative Standard Viscosity-Temperature Chart for Liquid Petroleum Products (D 341 – 32 T), submitted by Committee D-2 on Petroleum Products and Lubricants;

Tentative Method of Test for Modulus of Elasticity of Natural Building Stone (D 338 – 31 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Method of Shear Testing of Natural Building Stone (D 339 – 31 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Definitions of Terms Relating to Natural Building Stone (D 340 – 31 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Method of Bend Testing for Ductility of Metals (E 16 – 31 T), submitted by Committee E-1 on Methods of Testing;

Tentative Specifications for Round-Hole Screens for Testing Purposes (E 17 – 31 T), submitted by Committee E-1 on Methods of Testing.

Revisions of the following tentative standards were also approved by Committee E-10 and the tentative standards issued in their revised form during the year:

Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 31 T), submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought;

Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T), submitted by Committee D-13 on Textile Materials;

Tentative Method of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) (D 327 – 31 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Method of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (D 328 – 31 T), submitted by Committee D-18 on Natural Building Stones.

In addition to the new and revised tentative standards which were approved, proposed Tentative Specifications for Aluminum Alloy Wire, Rods, Bars were submitted to Committee E-10 by Committee B-7 on Light Metals and Alloys, Cast and Wrought. However, on the basis of the information furnished, Committee E-10 was not satisfied that it could approve the proposed specifications and they were accordingly referred back to Committee B-7.

Mention should also be made of an interim report presented to the Executive Committee by Committee A-7 on Malleable Iron

Castings indicating that at the approaching annual meeting of the Society the committee planned to recommend a revision of the Standard Specifications for Malleable Castings (A 47 – 30) in the form of proposed Tentative Specifications for Malleable Iron Castings.

Relations with American Standards Association:

Committee E-10 has followed the Society's relations with the American Standards Association, with particular reference to standards submitted to the A.S.A. for approval. Such standards fall in one of two categories, standards submitted on the recommendation of a sectional committee for which the Society is sponsor or joint sponsor, and standards that have not been considered by a sectional committee but which are submitted for approval under the proprietary sponsorship method. The latter method is particularly applicable to many A.S.T.M. standards since it contemplates approval by the A.S.A. of standards in respect to which it can be shown that they have been developed in such a way that the interests of all concerned have been adequately considered and that the standards are generally acceptable to and in use by industry. While very few standards were submitted under the proprietary sponsorship method this year, it is expected that the Society will take increasing advantage of the availability of this procedure in submitting existing A.S.T.M. standards to the A.S.A. for approval.

The following standards have been referred to the American Standards Association under the proprietary sponsorship method but have not as yet been approved:

Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 4 – 27);

Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 5 – 27).

Sectional Committee Personnel.—One new sectional committee has been organized during the year, namely, the Sectional Committee on Specifications for Sieves for Testing Purposes under the joint sponsorship of the Society and the U. S. Bureau of Standards. The Society is represented on this committee by Messrs. E. E. Eakins, O. O. Malleis and L. T. Work. The personnel in general includes the members of the Society's Committee on Sieves for Testing Purposes under the jurisdiction of Committee E-1 on Methods of Testing so that should any modifications of the existing standard specifications be recommended such modifications would come immediately to the attention of the A.S.T.M. committee having jurisdiction over these specifications and concurrent action can be taken.

There is now before the Electrical Standards Committee, which is the advisory committee of the American Standards Association on electrical subjects, a proposal to organize the Society's Committee D-9 on Electrical Insulating Materials as a sectional committee. This developed as a result of the cooperation in recent years of the Society with the U. S. National Committee of the International Electrotechnical Commission on insulating oils and, as recently proposed, on shellac and synthetic resins for insulating purposes.

Two new sectional committees have recently been organized under A.S.A. procedure in which the Society is interested; a Sectional Committee on Specifications for Clean Bituminous Coal on which the Society will be represented by Mr. W. D. Langtry and a Sectional Committee on Noise Measurement with the activities of which the Society will be kept in touch through the appointment of the Assistant Secretary as a liaison member.

Promotion and Expansion of Standardization Activities:

Several important projects comprising new standardization activities came up for consideration in Committee E-10 during the year. One of them has resulted definitely in the authorization of a new standing committee and several may lead to the organization of new committees.

Committee on Spectrographic Analysis.—The need for cooperative work on methods of spectrographic analysis was brought to the attention of Committee E-10 by Committee E-1 on Methods of Testing, the proposal having originated in Committee E-4 on Metallography. After a canvass of the industry it was found that there was a very definite interest in this subject and accordingly the Executive Committee has authorized the formation of a standing committee on this subject, the committee being designated Committee E-2 on Spectrographic Analysis. It is expected that definite organization will be effected during the approaching annual meeting of the Society.

Committee on Water Analysis.—Organization of the new standing committee on water analysis, referred to in the 1931 report of Committee E-10, has been effected during the year, the committee being designated Committee D-19 on Analysis of Industrial Waters.

Committee on Paper and Allied Products.—Mention was made in the report a year ago of the proposed organization of a new standing committee on paper and allied products. While discussions with the Technical Association of the Pulp and Paper Industry have indicated the desirability of the Society undertaking this work, it has not been possible to have organization completed prior to this annual meeting.

It is expected that the organization of the committee will be effected in the near future.

Heat Insulation.—The committee still has before it a suggestion that consideration be given to standards relating to heat insulation which may result in the organization of a new standing committee.

Die Steels.—In the report of the committee a year ago reference was made to a study that had been undertaken by representatives of Committees B-6 on Die-Cast Metals and Alloys and A-1 on Steel on how work on specifications for die steels should be organized. This has resulted in the organization of Subcommittee XXIII on Die Steels of Committee A-1 on Steel.

Wire and Wire Rope.—Committee A-1 on Steel is continuing its study on the part of the fact-finding committee to determine if any work might profitably be undertaken on specifications for wire and wire rope.

Adhesives.—The suggestion has been received from the Society's Committee D-10 on Shipping Containers that there is considerable need for specifications for glues and other types of adhesives. This would include the animal and vegetable glues and various other types. This will require considerable study in order to determine in what way the Society may best be of service.

Foundry Sands.—The committee still has before it a request from the American Foundrymen's Association that the Society give consideration to standard methods of testing foundry sands and specifications in this field, particularly with respect to the methods developed by a committee of the American Foundrymen's Association. No decision has as yet been reached as to how this work should proceed.

Non-Destructive Testing.—The question arose in Committee E-10 as to what work was being done by the Society in the field of non-destructive testing. Various non-destructive tests are in use or have been proposed including the following: magnetic analysis, electrical resistance tests, X-ray examination, gamma-ray examination, hardness tests, stethoscope test, iron filings test, whiting test, etc. Of these, methods of magnetic analysis have received considerable study on the part of the Society's Committee A-8 on Magnetic Analysis. Committee E-4 on Metallography has developed methods of radiographic testing and proposes to extend this work to include gamma-ray methods. Committee E-1 on Methods of Testing has developed methods of hardness testing. In view of the work already under way in these several committees the decision was reached that no general committee on non-destructive testing should be organized but that if the need arose Committee E-1 might organize a coordinating committee, which committee would work in cooperation with a committee on non-destructive tests functioning under the American Institute of Mining and Metallurgical Engineers.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

A.S.T.M.
TENTATIVE STANDARDS

ISSUED OR REVISED, 1932

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action toward its adoption as standard.

Members of the Society and others are invited to direct written criticism of any these Tentative Standards to the officer of the appropriate committee, whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
SOFT STEEL TRACK SPIKES[1]

A.S.T.M. Designation: A 65 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1932.

MANUFACTURE

Process. 1. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace or acid-bessemer.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 2. (*a*) The steel shall conform to the following requirements as to chemical composition:

	ACID-BESSEMER	OPEN-HEARTH OR ELECTRIC-FURNACE
Carbon, minimum, per cent...................	0.06	0.12

Ladle Analyses. 3. (*a*) A carbon determination shall be made of each melt of acid-bessemer steel and three determinations shall be made every 24 hours, one for each 8-hour turn respectively representing the average carbon content in the steel. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirement specified in Section 2.

(*b*) An analysis of each melt of open-hearth or electric-furnace steel shall be made by the manufacturer to determine the percentage of carbon. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirement specified in Section 2.

(*c*) Where ladle analysis cannot be furnished, the manufacturer shall furnish a report of the chemical analysis made on three spikes selected at random from each 10-ton lot.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Steel Track Spikes (A.S.T.M. Designation: A 65 - 24), 1930 Book of A.S.T.M. Standards, Part I, p. 59.

Physical Properties and Tests

Tensile Strength. 4. (*a*) The manufacturer may, at his option, substitute tension tests for the chemical analysis specified in Section 2, in which case the finished spikes shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 2 in., per cent	25

(*b*) When this option is exercised, one tension test shall be made from each 10-ton lot or fraction thereof.

Bend Tests. 5. (*a*) The body of the full-size finished spikes shall stand being bent cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(*b*) The head of the full-size finished spikes shall stand being bent backward to the line of the face of the spike, without cracking on the outside of the bent portion.

Number of Bend Tests. 6. One bend test of each kind specified in Section 5 (*a*) and (*b*) shall be made from each lot of 5 tons or fraction thereof.

Workmanship and Finish

Workmanship. 7. The finished spikes shall conform to the dimensions specified by the purchaser within the following permissible variations:

(*a*) A variation of $\frac{1}{32}$ in. over and $\frac{1}{64}$ in. under the specified cross-section dimensions of the body of the spike will be permitted.

(*b*) A variation of $\frac{3}{32}$ in. over and $\frac{1}{32}$ in. under the specified dimensions of the head of the spike will be permitted.

(*c*) A variation of $\frac{1}{8}$ in. from the specified length of the spike measured from the under size of the head to the point will be permitted.

(*d*) A variation of one degree in the specified angle of the under side of the head of the spike will be permitted.

Finish. 8. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

Inspection and Rejection

Inspection. 9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

10. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL MEDIUM STEEL[1]

A.S.T.M. Designation: A 140 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications are issued to supply standardized requirements for a constructional steel not usually carried in stock but occasionally specified for special work of heavy character; and that has an average tensile strength greater than the standard structural grade in general use. Rivet steel requirements are covered by the Tentative Specifications for Structural Rivet Steel (A.S.T.M. Designation: A 141 – 32 T)[2] of the American Society for Testing Materials. The Standard Specifications for Carbon-Steel and Alloy-Steel Forgings (A.S.T.M. Designation: A 18)[3] may also be used for forgings.

MANUFACTURE

Process. 2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

Phosphorus	Acid	not over 0.06 per cent
	Basic	not over 0.04 per cent
Sulfur		not over 0.05 per cent
Copper, when copper steel is specified		not less than 0.20 per cent

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur; also copper when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentages of phosphorus and sulfur, and copper when copper steel is specified, shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] See p. 540.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 178.

Check Analyses.

5. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. (*a*) The material shall conform to the following requirements as to tensile properties:

	PLATES, SHAPES AND BARS	EYEBAR FLATS UNANNEALED
Tensile strength, lb. per sq. in.	60 000 to 72 000	67 000 to 82 000[a]
Yield point, minimum, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
but in no case less than	33 000	36 000
Elongation in 8 in.,[b] minimum, per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$
Elongation in 2 in.,[c] minimum, per cent	22	20

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[a] See Paragraph (*b*).

[b] See Section 7.

[c] When Fig. 2 specimen is used; see Section 9 (*e*) and (*g*).

(*b*) When finished eyebars are subject to full-size tests, the physical properties required for specimen tests of the eyebar flats unannealed shall be determined by the manufacturer of the eyebars.

(*c*) When full-size tests are specified for finished, annealed eyebars they shall conform to the following requirements as to tensile properties:

Tensile strength, minimum, lb. per sq. in.	60 000
Yield point, minimum, lb. per sq. in.	33 000
Elongation in 18 ft., minimum, per cent	12

The elongation shall be measured in the body of the bar including the fracture. The fracture shall show a silky or finely granular structure throughout.

(*d*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 6 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of 16 per cent for plates, shapes and bars and a minimum of 14 per cent for eyebar flats unannealed.

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 6 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. in thickness or diameter below $\frac{5}{16}$ in.

Bend Tests. 8. The test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin, the diameter of which shall have the following relation to the thickness of the specimen:

THICKNESS OF MATERIAL	RATIO: $\frac{\text{PIN DIAMETER}}{\text{THICKNESS OF SPECIMEN}}$	
	PLATES, SHAPES AND BARS	EYEBAR FLATS UNANNEALED
Up to ¾ in., inclusive	1	1½
Over ¾ to 1 in., inclusive	1½	2½
Over 1 to 1½ in., inclusive	2	3
Over 1½ to 2 in., inclusive	2½	4
Over 2 to 2½ in., inclusive	3	4½

Test Specimens. 9. (*a*) Test specimens shall be prepared for testing from the material in its rolled or forged condition, except as specified in Paragraph (*b*).

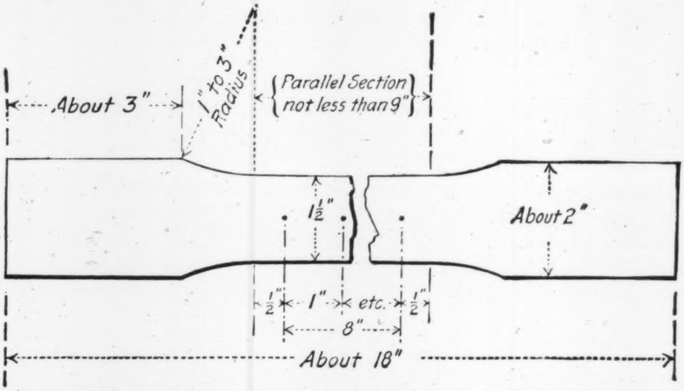


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) Test specimens for annealed material, except for eyebar flats unannealed, shall be prepared from the material as annealed for use, or from a short length of a full section similarly treated.

(*c*) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (*e*), (*f*), and (*g*), shall be of the full thickness or section of material as rolled.

(*d*) Test specimens for plates, shapes and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*e*) Tension test specimens for material over 1½ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

☞ (*f*) Bend test specimens for material over 1½ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least ¾ in. or to 1 by ½ in. in section.

(*g*) Tension test specimens for pins and rollers shall conform to the dimensions shown in Fig. 2, and bend test specimens shall be 1 by ½ in. in section.

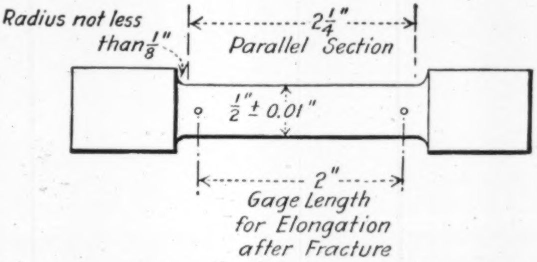
(*h*) Test specimens for pins and rollers shall be taken so that the axis is 1 in. from the surface.

(*i*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests.

10. (*a*) One tension and one bend test shall be made from each melt; except that if material from one melt differs ⅜ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.



Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Test Specimen.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations.

11. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weight of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*) and (*c*).

(*b*) *When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

ORDERED WEIGHT, LB. PER SQ. FT.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS																		ORDERED WEIGHT, LB. PER SQ. FT.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

ORDERED THICKNESS, IN.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHTS									ORDERED THICKNESS, IN.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	....	....	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	....	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

(*c*) *When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

FINISH

Finish. 12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking. 13. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

INSPECTION AND REJECTION

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL RIVET STEEL[1]

A.S.T.M. Designation: A 141 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Process. 1. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 2. The steel shall conform to the following requirements as to chemical composition:

Phosphorus	Acid	not over 0.06 per cent
	Basic	not over 0.04 per cent
Sulfur		not over 0.045 per cent
Copper, when copper steel is specified		not less than 0.20 per cent

Ladle Analyses. 3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur; also copper when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentages of phosphorus and sulfur, and copper when copper steel is specified, shall conform to the requirements specified in Section 2.

Check Analyses. 4. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 5. (*a*) The bars shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	52 000 to 62 000
Yield point, minimum, lb. per sq. in.	0.5 tens. str.
but in no case less than	28 000
Elongation in 8 in., minimum, per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Bend Tests.

6. The test specimen shall stand being bent cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

7. (*a*) Test specimens shall be of the full diameter of bars as rolled.

(*b*) Tension and bend test specimens for rivet bars which have been cold-drawn shall be normalized before testing.

Number of Tests.

8. (*a*) One tension and one bend test shall be made from each melt; except that if bars from one melt differ $\frac{3}{8}$ in. or more in diameter, one tension and one bend test shall be made from both the greatest and least diameters rolled.

(*b*) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN DIAMETER

Permissible Variations.

9. The diameter of rivet bars shall not vary from the size ordered more than the amounts given in the following table:

DIAMETER	VARIATIONS, IN.	
	OVER	UNDER
Up to and including ½ in.	0.007	0.007
Over ½ up to and including 1 in.	0.010	0.010
Over 1 up to and including 2 in.	$\frac{1}{32}$	$\frac{1}{64}$

FINISH

Finish.

10. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking.

11. Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

INSPECTION AND REJECTION

Inspection.

12. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which con-

cern the manufacture of the bars ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(*b*) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 4, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
STEEL PLATES OF FLANGE AND FIREBOX QUALITIES FOR FORGE WELDING[1]

A.S.T.M. Designation: A 89 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover two grades of steel plate of flange and firebox qualities suitable for forge welding without the use of fluxes where the weld is not reinforced.

MANUFACTURE

Process. 2. The steel shall be made by either or both the following processes: open-hearth or electric-furnace.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 3. (*a*) The steel shall conform to the following requirements as to chemical composition:

		FLANGE		FIREBOX	
		GRADE A	GRADE B	GRADE A	GRADE B
Carbon, maximum, per cent...	for plates ¾ in. or under in thickness..	0.15	0.20	0.15	0.20
	for plates over ¾ in. in thickness.........	0.17	0.22	0.17	0.22
Manganese, per cent............		0.35–0.60	0.35–0.60	0.35–0.60	0.35–0.60
Phosphorus, maximum, per cent ..	Acid......	0.06	0.06	0.04	0.04
	Basic.....	0.04	0.04	0.035	0.035
Sulfur, maximum, per cent..........		0.05	0.05	0.04	0.04

(*b*) The steel should preferably be free from nickel and chromium. When these elements are present the maximum quantity of either one shall not exceed 0.05 per cent. Unless otherwise specified, the silicon shall not exceed 0.05 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A 89 - 30), see 1930 Book of A.S.T.M. Standards, Part I, p. 127. These specifications are identical with the Standard Specifications except for the addition of requirements for firebox quality material, the inclusion of requirements for elongation in 2 in. for material over 1½ in., and in the nickel, silicon and chromium content in the case of material for fusion welding.

NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and/or chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	FLANGE		FIREBOX	
	GRADE A	GRADE B	GRADE A	GRADE B
Tensile strength, lb. per sq. in..	45 000	50 000	45 000[a]	50 000[a]
Yield point, lb. per sq. in.....	0.5 tens. str.	0.5 tens. str.	0.5 tens. str.	0.5 tens.str.
but in no case less than....	24 000	27 000	24 000	27 000
Elongation in 8 in.,[b] per cent..	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,550\,000}{\text{tens. str.}}$	$\frac{1\,550\,000}{\text{tens. str.}}$
Elongation in 2 in., per cent..	$\frac{1\,600\,000}{\text{tens. str.}}$	$\frac{1\,600\,000}{\text{tens. str.}}$	$\frac{1\,650\,000}{\text{tens. str.}}$	$\frac{1\,650\,000}{\text{tens. str.}}$

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[a] See Paragraph (*b*).

[b] See Section 7.

(*b*) Tensile strength only need be determined on the test specimen taken longitudinally from the top of firebox plates, and it shall not exceed 60,000 lb. per sq. in. for Grade A and 65,000 lb. per sq. in. for Grade B.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentages of elongation in 8 in. specified in Section 6 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests.

8. The test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For

material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. in length, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

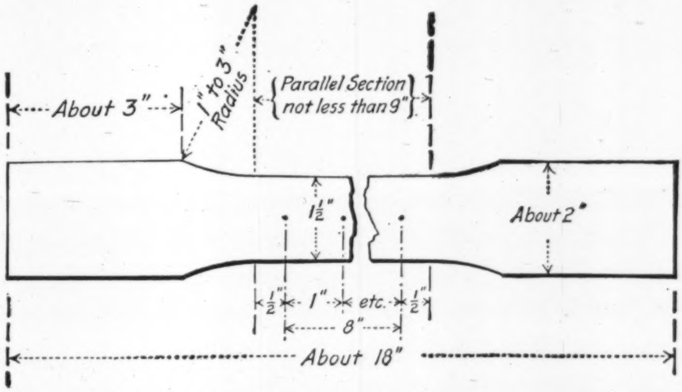


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

Test Specimens.

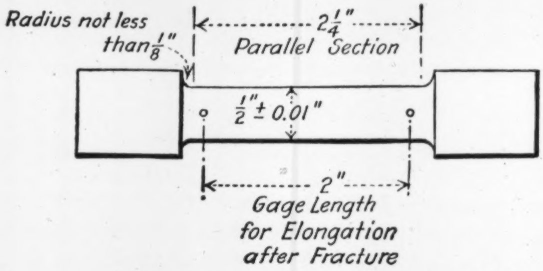
10. (*a*) Tension test specimens for firebox material shall be taken from the top and bottom corners of the plate as rolled, parallel to its longitudinal axis and for flange material from the bottom of the plate only. Bend test specimens shall be taken from the middle of the top of the plate as rolled, at right angles to its longitudinal axis.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, except as specified in Paragraphs (*c*) and (*d*), and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

(*c*) Tension test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(*d*) Bend test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. or to 1 by $\frac{1}{2}$ in. in section.

(*e*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Test Specimen.

Number of Tests. 11. (*a*) Two tension and one bend test shall be made from each firebox steel plate as rolled. One tension and one bend test shall be made from each flange steel plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations. 12. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] in each shipment shall not exceed

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The term "lot" applied to Table I means all of the plates of each group width and group thickness.

the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

FINISH

Finish

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking.

14. (*a*) The name or brand of the manufacturer, the manufacturer's test identification number, class, and lowest tensile strength for the grade specified in Section 6 (*a*) shall be legibly stamped on each plate. The manufacturer's test identification number shall be legibly stamped on each test specimen.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When the plate rolled from a slab or ingot is cut into two or more smaller plates, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match-mark shall consist of two over-lapping circles, each not less than 1½ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

INSPECTION AND REJECTION

Inspection. 15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
LAP-WELDED AND SEAMLESS STEEL AND LAP-WELDED IRON BOILER TUBES[1]

A.S.T.M. Designation: A 83 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932; REVISED, 1932.[2]

Scope. 1. These specifications cover lap-welded and seamless steel and lap-welded iron boiler tubes, boiler flues, superheater tubes, safe ends (Note) and arch tubes.

NOTE.—Grade C tubes are seamless. This grade is not suitable for safe ending by forge welding.

MANUFACTURE

Process. 2. (*a*) The material for lap-welded tubes shall be made by either or both of the open-hearth or electric-furnace processes, or by the knobbled, hammered charcoal-iron process.

(*b*) The steel for seamless tubes shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. (*a*) Chemical analysis will not be required for charcoal-iron tubes.

(*b*) Material made by the open-hearth or electric-furnace processes shall conform to the following requirements as to chemical composition:

	GRADE A LOW-CARBON STEEL	GRADE B OPEN-HEARTH IRON	GRADE C MEDIUM-CARBON STEEL
Carbon, per cent.........	0.08 to 0.18	not over 0.03	not over 0.35
Manganese, per cent......	0.30 to 0.60	not over 0.03	not over 0.80
Phosphorus, per cent......	not over 0.04	not over 0.02	not over 0.04
Sulfur, per cent...........	not over 0.045	not over 0.045	not over 0.045

Check Analyses. 4. (*a*) Analyses of two tubes in each lot of 250 lengths or fraction thereof, and in each lot of 2000 ft. or fraction thereof of safe-end material may be made by the purchaser. Drillings for analysis shall be taken from several points around each tube selected for analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A.S.T.M. Designation: A 83 - 30), 1930 Book of A.S.T.M. Standards, Part I, p. 238.

[2] Revision accepted by Committee E-10 on Standards, August 11, 1932.

(*b*) If the analysis of either tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

Flange Tests.

5. (*a*) For tubes not more than 6 in. in diameter and having a thickness less than 10 per cent of the outside diameter, and providing the thickness does not exceed No. 6 B.w.g. (0.203 in.), a test specimen not less than 4 in. in length shall be capable of having a flange turned over at right angles to the body of the tube without cracking or showing any flaw. This flange, as measured from the outside of the tube, shall in no case be less than ⅛ in. nor more than ½ in. Within these limits, the width of flange shall be not less than the following:

OUTSIDE DIAMETER OF TUBE, IN.	WIDTH OF FLANGE		
	CHARCOAL IRON	OPEN-HEARTH OR ELECTRIC FURNACE GRADES A AND B	GRADE C
Up to 2½, inclusive.......	12.5 per cent of outside diameter	15 per cent of outside diameter	75 per cent of that required for Grades A and B
Over 2½ to 3¾, inclusive..	⅜ in.	⅜ in.	
Over 3¾ to 6, inclusive...	10 per cent of outside diameter	10 per cent of outside diameter	

(*b*) For tubes other than specified in Paragraph (*a*) the flange test will not be required.

(*c*) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

Flattening Tests.

6. (*a*) For tubes, except Grade C, having a wall thickness not more than 10 per cent of the outside diameter, and providing the thickness does not exceed No. 6 B.w.g. (0.203 in.), a section of tube 2½ in. in length shall stand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

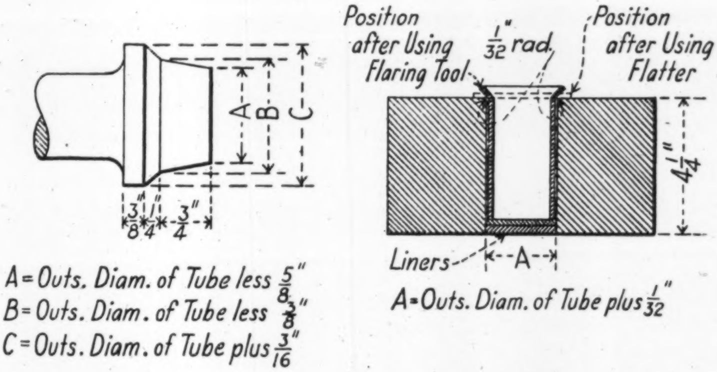
For seamless tubes: three times the wall thickness.
For lap-welded tubes: five times the wall thickness.

(*b*) For tubes, except Grade C, other than specified in Paragraph (*a*), a section of tube 2½ in. in length shall stand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

For seamless tubes: four times the wall thickness.
For lap-welded tubes: six times the wall thickness.

NOTE.—In the case of lap-welded wrought-iron tubes thicker than No. 6 B.w.g. (0.203 in.), the test shall be made with the weld 45 deg. away from the point of maximum bend. For other lap-welded wrought-iron tubes and for all steel lap-welded tubes covered by Paragraphs (*a*) and (*b*), the test shall be made with the weld at the point of maximum bend.

(*c*) For Grade C tubes, a section of tube not less than 2½ in. in length shall stand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is one-half the outside diameter of the tube, but in no case less than seven times the wall thickness.



A
B
C
3/8"
1/4"
3/4"
A = Outs. Diam. of Tube less 5/8"
B = Outs. Diam. of Tube less 3/8"
C = Outs. Diam. of Tube plus 3/16"
Position after Using Flaring Tool
1/32" rad.
Position after Using Flatter
4 1/4"
Liners
A
A = Outs. Diam. of Tube plus 1/32"

Flaring Tool

Die Block

FIG. 1.—Flaring Tool and Die Block for Flange Test.

Crush Tests.

7. When required by the inspector, crushing tests shall be made on sections of the tube 2½ in. in length which shall stand crushing longitudinally, without cracking, splitting or opening at the weld, as follows:

Steel Tubes, Grades A and B: No. 10 B.w.g. or lighter, to a height of ¾ in. or until outside folds are in contact; if heavier than No. 10 B.w.g., to a height of 1¼ in.

Steel Tubes, Grade C: Crush tests will not be required for this grade.

Charcoal-Iron Tubes: No. 10 B.w.g. or lighter, to a height of 1⅛ in.; if heavier than No. 10 B.w.g., to a height of 1½ in. Slight surface checks shall not be cause for rejection.

Tension Tests.

8. (*a*) Grade C tubes shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	60 000
Yield point, lb. per sq. in.	37 000
Elongation in 2 in., per cent	25

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by other approved method.

(*c*) Tension test specimens shall be cut longitudinally from the tube and not flattened between gage marks. The sides of the specimen shall be parallel between gage marks. If desired, the test specimen may consist of a full section of the tube, except where the tube in full section exceeds the capacity of the testing machine.

Hydrostatic Tests.

9. (*a*) Tubes under 5 in. in diameter shall withstand an internal hydrostatic pressure of 1000 lb. per sq. in., and tubes 5 in. or over in diameter shall withstand an internal hydrostatic pressure of 800 lb. per sq. in., provided the fiber stress corresponding to these pressures does not exceed 16,000 lb. per sq. in. for Grades A and B and 18,000 lb. per sq. in. for Grade C, as determined by the following formula. Should the fiber stress corresponding to these pressures exceed the above figures, the hydrostatic test pressure shall be determined by the following formula:

$$P = \frac{2St}{D}$$

where P = the hydrostatic test pressure in pounds per square inch;
S = the allowable fiber stress of 16,000 lb. per sq. in. for Grades A and B tubes and 18,000 lb. per sq. in. for Grade C tubes;
t = the thickness of tube wall in inches; and
D = the outside diameter of tube in inches.

(*b*) Lap-welded tubes shall be struck near both ends, while under the test pressure, with a 2-lb. steel-hand hammer or its equivalent.

Etch Tests for Charcoal-Iron Tubes.

10. To determine that a tube is charcoal iron, a cross-section of the tube may be turned or ground to a true surface, polished free from dirt or cracks, and etched[1] until the soft parts are sufficiently dissolved to show a decided ridged surface, with the weld very distinct. A steel tube so etched would show an even or homogeneous surface.

Test Specimens.

11. (*a*) Test specimens shall be taken from finished tubes. They shall be smooth on the ends and free from burrs.

(*b*). All specimens shall be tested at room temperature.

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[1] A solution of 10 per cent hydrochloric acid (sp. gr. 1.19), 30 per cent sulfuric acid (sp. gr. 1.84), and 60 per cent water; or 25 per cent nitric acid (sp. gr. 1.42) and 75 per cent water, is recommended for the etch test.

TABLE I.—STANDARD WEIGHTS OF LAP-WELDED AND SEAMLESS BOILER TUBES.
INCLUDING SAFE ENDS, ARCH TUBES AND LARGE BOILER TUBES

Thickness		Weight, lb. per ft. of length																						
		Outside Diameter, in.																						
B.w.g.	In.	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4½	5	5¼	5⅜	5½	6	7	8	9	10	11	12	13
13	0.095	1.679	1.932	2.186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	0.109	1.910	2.201	2.492	2.783	3.074	3.365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	0.120	2.089	2.409	2.729	3.050	3.370	3.691	4.011	4.331	4.652	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	0.134	2.312	2.670	3.028	3.386	3.743	4.101	4.459	4.817	5.175	5.532	6.248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	0.148	2.532	2.927	3.322	3.717	4.112	4.508	4.903	5.298	5.693	6.088	6.879	7.669	8.064	8.262	8.459	.....	.....	.....	.....	.....	.....	.....	.....
8	0.165	.....	3.233	.....	4.114	4.555	4.995	5.436	5.877	6.317	6.758	7.639	8.520	8.960	9.181	9.401	10.282	12.044	13.807	.....	.....	.....	.....	.....
7	0.180	.....	.....	.....	4.460	4.940	5.421	5.901	6.382	6.863	7.343	8.304	9.266	9.746	9.987	10.227	11.188	13.110	15.033	16.955	.....	.....	.....	.....
6	0.203	.....	.....	.....	4.980	5.522	6.064	6.606	.....	.....	8.232	9.316	10.400	.....	.....	.....	12.568	14.736	16.904	19.072	21.240	.....	.....	.....
5	0.220	.....	.....	.....	5.357	5.944	6.531	7.119	.....	.....	.....	.....	11.231	.....	.....	.....	13.580	15.930	18.280	20.629	22.979	25.329	.....	.....
4½	0.229	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.788	.....
4	0.238	.....	.....	.....	5.749	6.385	7.020	7.656	.....	.....	.....	.....	.....	.....	.....	.....	14.646	17.188	19.730	22.271	24.813	27.355	.....	32.439
3½	0.2482	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31.188	.....
3	0.258	.....	4.815	5.507	6.198	6.890	7.582	8.273	8.965	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.179	26.945	29.711	.....	35.243
2½	0.2715	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.008	.....
2	0.284	.....	.....	.....	6.721	.....	8.238	8.996	9.754	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.470	32.503	.....	38.569
1½	0.295	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.512	.....
1	0.300	.....	.....	.....	7.048	7.849	8.650	9.451	10.252	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.283	.....	40.69
½	0.320	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.918	.....
0	0.340	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.971

NOTE.—Seamless tubes are at present not available above 6 in. in outside diameter.

Number of Tests

12. (*a*) For Grades A and B, one each of the tests specified in Sections 5, 6 and 7 shall be made on each of two tubes from each lot of 250 tubes or fraction thereof, and each 2000 ft. or fraction thereof of safe-end material. For Grade C one each of the tests specified in Sections 5, 6 and 8 shall be made on each of two tubes from each lot of 250 tubes or fraction thereof.

(*b*) Each tube shall be subjected to the hydrostatic test specified in Section 9.

Retests.

13. If the results of the physical tests of either of the tubes selected for tests do not conform to the requirements specified in Sections 5, 6, 7 and 8, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

TABLE II.—STANDARD WEIGHTS OF SMALL SUPERHEATER TUBES.
SEAMLESS ONLY

Thickness		Weight, lb. per ft. of length											
		Outside Diameter, in.											
B.w.g.	In.	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$
18	0.049	0.301	0.334	0.367	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	0.058	0.351	0.390	0.429	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	0.065	0.389	0.432	0.476	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	0.072	0.425	0.473	0.521	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	0.083	0.480	0.535	0.591	0.647	0.702	.....	.....	.....	...	.....	.....	.....
13	0.095	0.537	0.601	0.664	0.727	0.791	.....	.....	.....	.....	.....	.....	.....
12	0.109	0.600	0.673	0.746	0.818	0.891	.....	.....	.....	.....	.....	.....	.....
11	0.120	0.647	0.717	0.807	0.887	0.967	1.047	1.127	.....	.....	.....	.....	.....
10	0.134	0.702	0.792	0.881	0.971	1.060	1.149	1.239	1.597	1.776	1.865	1.954	2.133
9	0.148	.....	.....	.....	.....	1.149	1.247	1.346	1.741	1.939	2.038	2.138	2.334
8	0.165	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.352	.....

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Standard Weights.

14. The standard weights for tubes of various outside diameters and thicknesses are given in Tables I and II.

NOTE.—The weights given in Tables I and II are theoretical and are based on tubes of the exact diameters and wall thicknesses shown. Minimum wall tubes, as called for in these specifications, will weigh from 10 to 15 per cent heavier than those shown depending on the size and wall thickness specified.

Permissible Variations.

15. Variations in outside diameter, wall thickness, weight and length, from those specified, shall not exceed the amounts shown in Table III.

The diameter measured at any point on the outer circumference on finished tubes shall not vary more than the amounts shown in Table III.

WORKMANSHIP AND FINISH

Finish.

16. Finished tubes shall be reasonably straight, free from injurious defects, shall have smooth ends, free from burrs, and shall have a workmanlike finish.

MARKING

Marking. 17. The name or brand of the manufacturer, the grade of material from which it is made, whether lap-welded steel or iron, and the hydrostatic pressure in pounds at which it was tested, shall be legibly stenciled on each tube.

INSPECTION AND REJECTION

Inspection. 18. (*a*) Unless otherwise specified, inspection and all tests, except check analyses, shall be made at the place of manufacture. When required, the manufacturer shall furnish the purchaser of each lot of tubes a statement as to the kind of material of which the tubes are made and that the tubes have been tested and have met all the requirements of these specifications.

TABLE III.—PERMISSIBLE VARIATIONS IN LAP-WELDED AND SEAMLESS BOILER TUBES.

Size, Outside Diameter	Outside Diameter (Including Out-of Roundness), in.		Wall Thickness, B.w g.				Weight per Foot, per cent				Length, in.	
			Cold Drawn		Hot Finished		Cold Drawn		Hot Finished		Over	Under
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under		
4 in. and under.....	$\frac{1}{64}$	$\frac{1}{32}$	2	0	3	0	15	0	$17\frac{1}{2}$	0	$\frac{3}{16}$	0
Over 4 in....	$\frac{1}{64}$	$\frac{3}{64}$	2	0	3	0	15	0	$17\frac{1}{2}$	0	$\frac{3}{16}$	0

(*b*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications.

Rejection. 19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 (*a*) shall be reported within five working days from the receipt of samples.

(*b*) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Superheater tubes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. Tubes which fail in any of the above operations will be rejected, and the manufacturer shall be notified.

Rehearing. 20. Samples tested in accordance with Section 4 (*a*) which represents rejected tubes, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

BLACK AND HOT-DIPPED ZINC-COATED (GALVANIZED) WELDED AND SEAMLESS STEEL PIPE FOR ORDINARY USES[1]

A.S.T.M. Designation: A 120 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and **suggestions,** and as such is subject to annual revision.

Issued, 1928; Revised, 1932.

Scope. 1. These specifications cover black and hot-dipped galvanized "standard weight," "extra strong," and "double extra strong" welded and seamless steel pipe. Pipe ordered under these specifications is intended for ordinary uses such as low pressure service in steam, water and gas lines, and is not intended for close bending or coiling, or high-temperature service.

MANUFACTURE

Process. 2. (*a*) The steel for welded pipe shall be soft weldable quality made by the open-hearth, the electric-furnace or the acid-bessemer process. The steel for seamless pipe shall be made by the open-hearth or the electric-furnace process.

(*b*) Welded pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 in. in nominal diameter shall be lap-welded.

Galvanized Pipe. 3. Galvanized pipe shall be coated with zinc inside and outside by the hot-dip process.

HYDROSTATIC TESTS

Hydrostatic Tests. 4. Each length of pipe shall be tested at the mill to the hydrostatic pressures specified in Table I. Welded pipe 2 in. and larger shall be jarred near one end while under test pressure.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Standard Weights.

5. (*a*) The standard weights for pipe of various inside diameters are given in Table II.

(*b*) Nipples shall be cut from pipe of the same weight and quality described in these specifications.

Permissible Variations.

6 (*a*). *Weights.*—The weight of the pipe shall not vary more than 5 per cent for standard weight and extra strong pipe nor more than 10 per cent for double extra strong pipe from that specified in Table II.

(*b*) *Diameter.*—For pipe $1\frac{1}{2}$ in. or under in nominal diameter, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard specified. For pipe 2 in. or over in nominal diameter, the outside diameter shall not vary more than 1 per cent over or under the standard specified.

TABLE I.—HYDROSTATIC PRESSURES FOR WELDED AND SEAMLESS STEEL PIPE.
(Pressures Expressed in Pounds per Square Inch)

Size (Nominal Inside Diameter), in.	"Standard Weight" Pipe			"Extra Strong" Pipe			"Double Extra Strong" Pipe	
	Weight of Pipe per Linear Foot, Threaded and with Couplings	Butt-weld	Lap-weld and Seamless	Weight of Pipe per Linear Foot, Plain Ends, lb.	Butt-weld	Lap-weld and Seamless	Butt-weld	Lap-weld and Seamless
$\frac{1}{8}$	.....	700	....	.....	700	....	....	....
$\frac{1}{4}$	.....	700	....	.....	700	....	....	....
$\frac{3}{8}$	.....	700	....	.....	700	....	....	....
$\frac{1}{2}$	.....	700	....	.....	700	....	700	....
$\frac{3}{4}$	.....	700	....	.....	700	....	700	....
1	.....	700	....	.....	700	....	700	....
$1\frac{1}{4}$	.....	700	1000	.....	1500	2500	2200	....
$1\frac{1}{2}$	.....	700	1000	.....	1500	2500	2200	3000
2	.....	700	1000	.....	1500	2500	2200	3000
$2\frac{1}{2}$	.....	800	1000	.....	1500	2000	2200	3000
3	.....	800	1000	.....	1500	2000	2200	3000
$3\frac{1}{2}$	.....	...	1000	.....	....	2000	....	2500
4	.....	...	1000	.....	....	2000	....	2500
5	.....	...	1000	.....	....	1800	....	2000
6	.....	...	1000	.....	....	1800	....	2000
8	25.00	...	800	.....	....	....	....	2000
8	28.81	...	1000	43.39	....	1500	....	....
10	32.00	...	600	.....	....	....	....	....
10	35.00	...	700	.....	....	....	....	....
10	41.13	...	900	54.74	....	1000	....	....
12	45.00	...	600	.....	....	....	....	....
12	50.71	...	800	65.42	....	1000	....	....

For pipes over 12 in. in inside diameter, the test pressures should be calculated by the formula $P = \frac{2St}{D}$ in which P = pressure in pounds per square inch; S = fiber stress, 12,000 lb. per sq. in. t = thickness of wall in inches; D = outside diameter in inches.

(*c*) *Thickness.*—The minimum wall thickness at any point shall not be more than 12.5 per cent under the nominal wall thickness.

Lengths. 7. Unless otherwise specified, pipe lengths shall be in accordance with the following regular practice:

(*a*) Standard weight pipe shall be in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be in lengths of 12 to 16 ft.

(*b*) Extra strong and double extra strong pipe shall be in random lengths of 12 to 22 ft. Five per cent may be in lengths of 6 to 12 ft.

TABLE II.—STANDARD WEIGHTS AND DIMENSIONS OF WELDED AND SEAMLESS STEEL PIPE.

Size (Nominal Inside Diameter), in.	Outside Diameter, in.	"Standard Weight" Pipe			"Extra Strong" Pipe		"Double Extra Strong" Pipe	
		Number of Threads per Inch	Thickness, in.	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Thickness, in.	Weight of Pipe per Linear Foot, Plain Ends, lb.	Thickness, in.	Weight of Pipe per Linear Foot Plain Ends, lb.
$\frac{1}{8}$	0.405	27	0.068	0.25	0.095	0.31	.....	.....
$\frac{1}{4}$	0.540	18	0.088	0.43	0.119	0.54	.....	.....
$\frac{3}{8}$	0.675	18	0.091	0.57	0.126	0.74	.....	.....
$\frac{1}{2}$	0.840	14	0.109	0.85	0.147	1.09	0.294	1.71
$\frac{3}{4}$	1.050	14	0.113	1.13	0.154	1.47	0.308	2.44
1........	1.315	$11\frac{1}{2}$	0.133	1.68	0.179	2.17	0.358	3.66
$1\frac{1}{4}$	1.660	$11\frac{1}{2}$	0.140	2.28	0.191	3.00	0.382	5.21
$1\frac{1}{2}$	1.900	$11\frac{1}{2}$	0.145	2.73	0.200	3.63	0.400	6.41
2........	2.375	$11\frac{1}{2}$	0.154	3.68	0.218	5.02	0.436	9.03
$2\frac{1}{2}$	2.875	8	0.203	5.82	0.276	7.66	0.552	13.70
3........	3.500	8	0.216	7.62	0.300	10.25	0.600	18.58
$3\frac{1}{2}$	4.000	8	0.226	9.20	0.318	12.51	0.636	22.85
4........	4.500	8	0.237	10.89	0.337	14.98	0.674	27.54
5........	5.563	8	0.258	14.81	0.375	20.78	0.750	38.55
6	6.625	8	0.280	19.19	0.432	28.57	0.864	53.16
*8........	8.625	8	0.277	25.00	.....	.....	0.875	72.42
8........	8.625	8	0.322	28.81	0.500	43.39	.....	....
*10........	10.750	8	0.279	32.00	.....	.....	.....	.....
*10........	10.750	8	0.307	35.00	.....	.....	.....	.....
10........	10.750	8	0.365	41.13	0.500	54.74	.....	.....
*12........	12.750	8	0.330	45.00	.....	.....	.....	.....
12........	12.750	8	0.375	50.71	0.500	65.42	.....	.....

[*] Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12 in. in nominal inside diameter, with threaded ends and couplings; sizes larger than those shown in the table are measured by the outside diameter and will be furnished with plain ends unless otherwise specified; for such sizes it will be necessary to accept Manufacturers' weights or calculate the weights on the basis of one cubic inch of steel weighing 0.2833 lb

WORKMANSHIP AND FINISH

Ends. 8. Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of standard weight welded pipe shall be threaded. Extra strong welded pipe and standard weight and extra strong seamless pipe and all double extra strong pipe shall be furnished with plain ends.

(*b*) All threads shall be in accordance with the American Standard Pipe Thread[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. **Threads.**

(*c*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be of wrought iron or steel. **Couplings.**

9. (*a*) The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed. **Finish.**

(*b*) The zinc coating on galvanized pipe shall be free from injurious defects or excessive roughness.

INSPECTION AND REJECTION

10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection**

11. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

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[1] A complete description of the American Standard Pipe Threads applicable to pipe valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, A.S.A. No. B2-1919.

TENTATIVE SPECIFICATIONS
FOR
ELECTRIC-FUSION-WELDED STEEL PIPE[1]
(SIZES 30 IN. AND OVER)

A.S.T.M. Designation: A 134 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover steel pipe 30 in. in diameter and over, with a wall thickness up to $\frac{3}{4}$ in. inclusive, manufactured by the electric-fusion-welding process.

MATERIAL

Plates. 2. The steel plate shall conform to the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A.S.T.M. Designation: A 78) or the Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A.S.T.M. Designation: A 89) of the American Society for Testing Materials,[2] or other A.S.T.M. specifications for equally suitable weldable material as specified.[3]

MANUFACTURE

Manufacture. 3. The longitudinal edges of the plate shall be shaped to give the most satisfactory results in electric-fusion welding. The plate shall then be properly formed and may be tacked preparatory to welding. The weld shall be made by automatic means and shall be of reasonably uniform width and height for the entire length of the pipe.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] 1930 Book of A.S.T.M. Standards, Part I, pp. 122 to 130.

[3] It is the opinion of Committee A-1 on Steel that steel made in accordance with the following specifications of the American Society for Testing Materials can be welded satisfactorily by the usual fusion-welding processes now in general use:

Standard Specifications for Structural Steel for Bridges (A 7), Structural Steel for Buildings (A 9), Structural Steel for Locomotives and Cars (A 113), Boiler and Firebox Steel for Locomotives (A 30), Boiler and Firebox Steel for Stationary Service (A 70), Steel Plates of Structural Quality for Forge Welding (A 78), Steel Plates of Flange Quality for Forge Welding (A 89), and Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 32 T), Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T), Structural Steel for Ships (A 131 – 31 T), and Structural Medium Steel (A 140 – 32 T).

In connection with carbon limitations in the above specifications, the committee was of the opinion that, while higher carbon steels are successfully welded, commercial practice at present often limits the carbon (by ladle test) to 0.30 per cent in open-hearth steel and 0.15 per cent in bessemer steel.

PHYSICAL PROPERTIES AND TESTS

4. If required by the purchaser, the test specimen taken across the weld shall show a tensile strength not less than the minimum tensile strength specified for the plate. **Tension Test.**

5. If required by the purchaser, the test specimen taken across the weld shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to $4\frac{1}{2}$ times the thickness of the plate, without developing cracks. In making the bend test, the side of the specimen representing the inside of the pipe shall be placed next the pin. **Bend Test.**

6. (*a*) Unless otherwise specified, each length of pipe shall be tested at the mill to a hydrostatic pressure equal to 150 per cent of the working pressure but in no case shall the test stress exceed 36 per cent of the minimum tensile strength specified. The working pressure shall be calculated from the following formula: **Hydrostatic Test.**

$$P = \frac{2\,St}{D}$$

where P = the working pressure in pounds per square inch;
S = the allowable fiber stress in pounds per square inch;
t = the wall thickness in inches, and
D = the outside diameter in inches.

(*b*) While under test pressure the pipe shall be jarred with a 2-lb. hammer or its equivalent.

7. (*a*) If required by the purchaser, test specimens shall be taken across the weld and from the end of the pipe or at any point in the pipe required by the inspector and shall be cut perpendicularly to the axis of the pipe with the weld approximately in the middle of the specimen. The tension test specimen shall be flattened and the sides shall be machined. The bend test specimen shall have the protruding portions of the weld, from both inside and outside of the pipe, removed by machining or grinding. **Test Specimens.**

(*b*) All specimens shall be tested at room temperature.

(*c*) The openings resulting from the removal of test specimens shall be patched in a manner approved by the purchaser.

8. (*a*) From each lot of 100 lengths or fraction thereof the purchaser may select at random one pipe for the tests specified in Sections 4 and 5. **Number of Tests.**

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 6.

Retests.

9. (*a*) If the results of the tension or bend tests of any lot do not conform to the requirements specified in Sections 4 and 5, retests of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

(*b*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Permissible Variations.

10. (*a*) *Weight.*—Tolerances on theoretical weights of pipe shall be governed by weight tolerances for plates as covered in specifications of the American Society for Testing Materials to which the plates are ordered.

(*b*) *Diameter.*—The outside diameter of the pipe shall be within tolerances consistent with the requirements of field joints as arranged by agreement with the purchaser.

Lengths.

11. Standard lengths of pipe shall be approximately 30 to 40 ft. Not more than 2 per cent of the total number of lengths may be shorter than 30 ft., excepting in the case of specials, such as reducers, etc. On pipe of larger diameter one or more circumferential joints may be made by welding or riveting, as specified.

WORKMANSHIP AND FINISH

Workmanship and Finish.

12. The finished pipe shall be reasonably straight, sized at the ends as required, and free from injurious defects.

Repairing Defects.

13. The welding of injurious defects in the pipe wall, provided their depth does not exceed one-third the specified wall thickness, will be permitted. Defects in the welds such as sweats or leaks, unless otherwise specified, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then welding. All repaired pipe shall be retested hydrostatically.

PROTECTIVE COATING

Protective Coating.

14. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating of the kind and in the manner specified by the purchaser.

INSPECTION AND REJECTION

15. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

16. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

TENTATIVE SPECIFICATIONS
FOR
ELECTRIC-FUSION-WELDED STEEL PIPE[1]
(SIZES 8 IN. TO BUT NOT INCLUDING 30 IN.)

A.S.T.M. Designation: A 139 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover two grades of electric-fusion-welded steel pipe in sizes 8 in. to but not including 30 in. in diameter, and wall thicknesses up to $\frac{5}{8}$ in. inclusive, which is intended for conveying liquid, gas or vapor at temperatures below 450° F. and is adapted for flanging and bending. The suitability of pipe for various purposes is somewhat dependent upon its dimensions and properties and conditions of service, so that the purpose for which the pipe is intended should be stated in the order.[2]

MANUFACTURE

Process. 2. Unless otherwise specified, the steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.060

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] It is the opinion of Committee A-1 on Steel that steel made in accordance with the following specifications of the American Society for Testing Materials can be welded satisfactorily by the usual fusion-welding processes now in general use. Therefore, if desired by purchaser, material ordered under any of the following specifications may be substituted for that specified in Sections 3 and 6:

Standard Specifications for Structural Steel for Bridges (A 7), Structural Steel for Buildings (A 9), Structural Steel for Locomotives and Cars (A 113), Boiler and Firebox Steel for Locomotives (A 30), Boiler and Firebox Steel for Stationary Service (A 70), Steel Plates of Structural Quality for Forge Welding (A 78), Steel Plates of Flange Quality for Forge Welding (A 89), and Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 32 T), Open-Hearth Iron Plates of Flange Quality (A 129 - 30 T), Structural Steel for Ships (A 131 - 31 T), and Structural Medium Steel (A 140 - 32 T).

In connection with carbon limitations in the above specifications, the committee was of the opinion that, while higher carbon steels are successfully welded, commercial practice at present often limits the carbon (by ladle test) to 0.30 per cent in open-hearth steel.

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analyses. 5. (*a*) Analyses of two pipe from each lot of 200 lengths or fraction thereof of each size 8 in. to 20 in., and from each lot of 100 lengths or fraction thereof of each size over 20 in. up to 30 in., may be made by the purchaser from the finished pipe. By agreement between the manufacturer and the purchaser, the analysis may be made on the skelp and the number shall be determined in the same manner as when taken from the finished pipe. The chemical composition thus determined shall conform to the requirements specified in Section 3. Drillings for analysis shall be taken from several points around each pipe, or across each piece of skelp, selected for analysis.

(*b*) *Retests.*—If the analysis of either length of pipe or length of skelp does not conform to the requirements specified in Section 3, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	GRADE A	GRADE B
Tensile strength, lb. per sq. in.	48 000	60 000
Yield point, lb. per sq. in.	30 000	35 000
Elongation in 2 in., per cent	30	25

(*b*) The yield point shall be determined by the drop of the beam of the testing machine or other approved method.

(*c*) The tensile strength across the weld shall be not less than the minimum tensile strength of the grade of steel ordered.

Bend Tests. 7. If required by the purchaser, the test specimen taken across the weld shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to $4\frac{1}{2}$ times the thickness of the plate, without developing cracks. In making the bend test, the side of the specimen representing the inside of the pipe shall be placed next the pin.

Hydrostatic Tests. 8. (*a*) Pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the minimum hydrostatic test pressure in pounds per square inch;

S = the allowable fiber stress: 16,000 to 18,000 lb. per sq. in. for Grade A; 20,000 to 22,000 lb. per sq. in. for Grade B, but in no case shall the hydrostatic pressure exceed 2500 lb. per sq. in. The stress produced shall not be more than 80 per cent of the specified yield point.

t = the wall thickness in inches; and

D = the outside diameter in inches.

(*b*) The hydrostatic pressure shall be maintained for not less than 5 seconds and, while under test pressure, the pipe shall be jarred near both ends with a 2-lb. hammer or its equivalent.

Test Specimens.

9. (*a*) Longitudinal tension test specimens shall be taken from the end of the pipe at a point approximately 90 deg. from the weld, and shall not be flattened between gage marks. Transverse tension test specimens shall be taken across the weld and from the same end of the pipe as the longitudinal test specimen. The sides of each specimen shall be parallel between gage marks. When impracticable to pull a test specimen in full thickness the A.S.T.M. standard 2-in. gage length test specimen may be used. By agreement between the manufacturer and the purchaser, the longitudinal tension test specimen may be taken from the skelp.

(*b*) The bend test specimen shall have the protruding portions of the weld, from both inside and outside of the pipe, removed by machining or grinding.

(*c*) All specimens shall be tested at room temperature.

(*d*) Where specimens are taken from points other than the ends of pipe, the openings resulting from the removal of test specimens shall be patched in a manner approved by the purchaser.

Number of Tests.

10. (*a*) One longitudinal and one transverse tension test and one bend test shall be made on one length from each lot of 200 lengths or fraction thereof of each size 8 in. up to 20 in., and on one length from each lot of 100 lengths or fraction thereof of each size 20 in. up to 30 in. When taken from the skelp, the number of tests shall be determined in the same manner as when taken from the finished pipe.

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 8.

Retests.

11. (*a*) If the results of the tension or bend tests of any lot do not conform to the requirements specified in Sections 6 and 7, two retests for each failure shall be made from separate lengths of the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen, as indicated by scribe scratches marked on the specimen before testing, the specimen may be discarded and another substituted.

(*c*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS, AND PERMISSIBLE VARIATIONS

Permissible Variations.

12. (*a*) *Weight.*—The weight of any length of pipe shall not vary more than 3.5 per cent under or 10 per cent over that specified, but the carload weight shall be not more than 1.75 per cent under the nominal weight.

(*b*) *Diameter.*—The outside diameter shall not vary more than 1 per cent over or under the nominal size specified.

(*c*) *Ends, Plain End Pipe.*—Unless otherwise specified, plain end pipe for use with the Dresser or Dayton type coupling shall be reamed both outside and inside sufficiently to remove all burrs. Plain end pipe for welding shall be beveled on the outside to an angle of 45 deg. with a width of flat at the end of the pipe of $\frac{1}{16}$ in. ± $\frac{1}{32}$ in. Where material is ordered beveled to any other than a 45-deg. angle it should be understood that the angle is to be measured from a line drawn perpendicular to the axis of the pipe. This means that a greater amount of material is removed with a 60-deg. angle than with a 45-deg. angle.

Pipe shall be sufficiently free from indentations, projections, or roll marks for a distance of 8 in. from the end of the pipe to make a tight joint with the rubber gasket type of coupling.

All plain end pipe intended for Dresser or Dayton type joints or for welding sizes $10\frac{3}{4}$ in. in outside diameter and smaller, shall be not more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{1}{16}$ in. larger than the nominal outside diameter of the pipe. Sizes larger than $10\frac{3}{4}$ in. in outside diameter shall be not more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the nominal outside diameter of the pipe.

(*d*) *Ends, Threaded Pipe.*—Each end of threaded pipe shall be reamed to remove all burrs. All threads shall be in accordance with the American Standard Pipe Threads[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard when tested with the standard working gage shall not exceed one and one-half turns either way. Pipe shall not be rounded-out by hammering in order to get a full thread. There shall be not more than two black threads for ¾-in. taper among the perfect threads. Black threads should not be confused with imperfect threads, such as torn, shaven, or broken.

(*e*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint.

(*f*) *Thickness.*—Minimum wall thickness at any point shall be not more than 12.5 per cent under the nominal wall thickness specified.

Lengths.

13. Unless otherwise specified, pipe shall be furnished in lengths averaging 38 ft. or over, with a minimum length of 20 ft., but not more than 5 per cent may be under 32 ft. Jointers made by welding are permissible. Where threaded pipe is ordered, jointers shall be made by threading and shall not exceed 5 per cent of the order.

WORKMANSHIP AND FINISH

Workmanship and Finish.

14. The finished pipe shall be reasonably straight and free from injurious defects (Note). Defects in excess of 12.5 per cent of the nominal wall thickness shall be considered injurious.

NOTE.—The weld shall show thorough penetration and good fusion with no appreciable under-cutting and shall be at least flush with the surface of the pipe. The metal shall not project more than 30 per cent for pipe ⅜ in. in thickness or less and 25 per cent for pipe over that thickness.

Repairing Defects.

15. (*a*) Welding by electric fusion of injurious defects in the pipe wall will be permitted, provided their depth does not exceed one-third the specified wall thickness.

(*b*) Minor defects in the welds, such as sweats or leaks, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then fusion welding.

(*c*) All repaired pipe shall be retested hydrostatically.

MARKING

Marking.

16. Each length of pipe shall be marked with appropriate symbols by stenciling, stamping, or rolling to show by whom manufactured, the grade of pipe, and that it conforms to these specifications.

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[1] A complete description of American Standard Pipe Threads applicable to pipe, valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, A.S.A. Standard No. B 2–1919.

PROTECTIVE COATING

17. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall then be given a protective coating as specified. **Protective Coating.**

INSPECTION AND REJECTION

18. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the inspection of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

TENTATIVE SPECIFICATIONS

FOR

ELECTRIC-RESISTANCE-WELDED STEEL PIPE[1]

A.S.T.M. Designation: A 135 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover two grades of electric-resistance-welded steel pipe in sizes up to and including 30 in. in diameter, which is intended for conveying liquid, gas or vapor at temperatures below 450° F. and is adapted for flanging and bending in the smaller sizes. The suitability of pipe for various purposes is somewhat dependent upon its dimensions and properties and conditions of service, so that the purpose for which the pipe is intended should be stated in the order.

MANUFACTURE

Process. 2. Unless otherwise specified, the steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.060

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analyses. 5. (*a*) Analyses of two pipe from each lot of 400 lengths or fraction thereof of each size under 6 in., and from each lot of 200 lengths or fraction thereof of each size 6 to 20 in., and from each lot of 100 lengths of each size over 20 in. and up to 30 in., may be made by the purchaser from the finished pipe. By agreement between the manufacturer and the purchaser, the analysis may be made on the skelp and the number shall be determined in the same manner as when taken from the finished pipe. The chemical composition thus determined shall conform to the requirements specified in Section 3. Drillings for analysis shall be taken from several points around each pipe, or across each piece of skelp, selected for analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

(*b*) *Retests.*—If the analysis of either length of pipe or length of skelp does not conform to the requirements specified in Section 3, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. (*a*) The pipe shall conform to the following minimum requirements as to tensile properties:

	GRADE A	GRADE B
Tensile strength, lb. per sq. in.	48 000	60 000
Yield point, lb. per sq. in.	30 000	35 000
Elongation in 2 in., per cent	30	25

(*b*) The yield point shall be determined by the drop of the beam of the testing machine or other approved method.

(*c*) The tensile strength across the weld shall be not less than the minimum tensile strength of the grade of pipe ordered. This test will not be required for pipe under 6 in. in outside diameter.

Flattening Tests.

7. Both crop ends from each length of pipe shall be flattened between parallel plates with the weld at the point of maximum bending until opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two-thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the weld shall occur until the distance between the plates is less than one-third of the original outside diameter of the pipe, but in no case less than five times the thickness of the pipe wall. Evidence of lamination or burnt material shall not develop during the entire flattening process, and the weld shall not show injurious defects.

Hydrostatic Tests.

8. (*a*) Pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the minimum hydrostatic test pressure in pounds per square inch;

S = the allowable fiber stress: 16,000 to 18,000 lb. per sq. in. for Grade A; 20,000 to 22,000 lb. per sq. in. for Grade B, but in no case shall the hydrostatic pressure exceed 2500 lb. per sq. in. The stress produced shall be not more than 80 per cent of the specified yield point.
t = the wall thickness in inches; and
D = the outside diameter in inches.

(*b*) The hydrostatic pressure shall be maintained for not less than 5 seconds and, while under test pressure, the pipe shall be jarred near both ends with a 2-lb. hammer or its equivalent.

Test Specimens.

9. (*a*) Longitudinal tension test specimens shall be taken from the end of the pipe at a point approximately 90 deg. from the weld, and shall not be flattened between gage marks. Transverse tension test specimens shall be taken across the weld and from the same end of the pipe as the longitudinal test specimen. The sides of each specimen shall be parallel between gage marks. When impracticable to pull a test specimen in full thickness the A.S.T.M. standard 2-in. gage length test specimen may be used. By agreement between the manufacturer and the purchaser, the longitudinal tension test specimen may be taken from the skelp.

(*b*) All specimens shall be tested at room temperature.

Number of Tests.

10. (*a*) One longitudinal tension test shall be made on one length from each lot of 400 lengths or fraction thereof of each size under 6 in., and one longitudinal and, if requested by the purchaser, one transverse tension test on one length from each lot of 200 lengths or fraction thereof of each size 6 to 20 in., and from each lot of 100 lengths or fraction thereof of each size over 20 in. and up to 30 in.

(*b*) The flattening test specified in Section 7 shall be made on both crop ends cut from each length of pipe.

(*c*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 8.

Retests.

11. (*a*) If the results of the tension tests of any lot do not conform to the requirements specified in Section 6, two retests for each failure shall be made from separate lengths of the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen, as indicated by scribe scratches marked on the specimen before testing, the specimen may be discarded and another substituted.

(*c*) If any section fails when flattening tests are made on the crop ends of each length of pipe, other pieces from the length may be cut until satisfactory tests are obtained, otherwise the length shall be rejected. Precautions shall be taken so that crop ends may be identified with respect to the length from which they were cut.

(*d*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS, AND PERMISSIBLE VARIATIONS

Permissible Variations.

12. (*a*) *Weight.*—The weight of any length of pipe shall not vary more than 3.5 per cent under or 10 per cent over that specified, but the carload weight shall not be more than 1.75 per cent under the nominal weight.

(*b*) *Diameter.*—The outside diameter shall not vary more than 1 per cent over or under the nominal size specified.

(*c*) *Ends, Plain End Pipe.*—Unless otherwise specified, plain end pipe for use with the Dresser or Dayton type coupling shall be reamed both outside and inside sufficiently to remove all burrs. Plain end pipe for welding shall be beveled on the outside to an angle of 45 deg. with a width of flat at the end of the pipe of $\frac{1}{16}$ in. ± $\frac{1}{32}$ in. Where material is ordered beveled to any other than a 45-deg. angle it should be understood that the angle is to be measured from a line drawn perpendicular to the axis of the pipe. This means that a greater amount of material is removed with a 60-deg. angle than with a 45-deg. angle.

Pipe shall be sufficiently free from indentations, projections, or roll marks for a distance of 8 in. from the end of the pipe to make a tight joint with the rubber gasket type of coupling.

For all plain end pipe intended for Dresser or Dayton type joints or for welding; sizes $10\frac{3}{4}$ in. in outside diameter and smaller, shall not be more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{1}{16}$ in. larger than the nominal outside diameter of the pipe. Sizes larger than $10\frac{3}{4}$ in. in outside diameter shall not be more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the nominal outside diameter of the pipe.

(*d*) *Ends, Threaded Pipe.*—Each end of threaded pipe shall be reamed to remove all burrs. All threads shall be in accordance with the American Standard Pipe Threads[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard when tested with the standard working gage shall not exceed one and one-half turns either way. Pipe shall not be rounded-out by hammering in order to get a full thread. There shall be not more than two black threads for $\frac{3}{4}$-in. taper among the perfect threads. Black threads should not be confused with imperfect threads, such as torn, shaven, or broken.

(*e*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint.

(*f*) *Thickness.*—Minimum wall thickness at any point shall be not more than 12.5 per cent under the nominal wall thickness specified.

Lengths. 13. Unless otherwise specified, pipe shall be furnished in lengths averaging 38 ft. or over, with a minimum length of 20 ft., but not more than 5 per cent may be under 32 ft. Jointers made by welding are permissible. Where threaded pipe is ordered, jointers shall be made by threading and shall not exceed 5 per cent of the order.

WORKMANSHIP AND FINISH

Workmanship and Finish. 14. The finished pipe shall be reasonably straight and free from injurious defects. Defects in excess of 12.5 per cent of the nominal wall thickness shall be considered injurious.

Repairing Defects. 15. (*a*) Electric welding of injurious defects in the pipe wall will be permitted, provided their depth does not exceed one-third the specified wall thickness.

(*b*) Minor defects in the welds, such as sweats or leaks, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then electric welding.

(*c*) All repaired pipe shall be retested hydrostatically in accordance with Section 8.

MARKING

Marking. 16. Each length of pipe shall be marked with appropriate symbols by stenciling, stamping, or rolling to show by whom manufactured, the grade of pipe, and that it conforms to these specifications.

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[1] A complete description of American Standard Pipe Threads applicable to pipe, valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, A.S.A. Standard No. B 2-1919.

PROTECTIVE COATING

17. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall then be given a protective coating as specified. **Protective Coating.**

INSPECTION AND REJECTION

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the inspection of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

TENTATIVE SPECIFICATIONS
FOR
FORGE-WELDED STEEL PIPE[1]

A.S.T.M. Designation: A 136 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover two grades of forge-welded pipe in sizes 14 in. to and including 96 in. in diameter, and wall thicknesses from $\frac{1}{4}$ to $1\frac{1}{4}$ in., inclusive, which is intended for various uses. The suitability of pipe for various purposes is somewhat dependent upon its dimensions and properties and conditions of service, so that the purpose for which the pipe is intended should be stated in the order.

MATERIAL

Process. 2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

NOTE.—It is recommended that steel plates be ordered to the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A.S.T.M. Designation: A 78) of the American Society for Testing Materials.[2] The Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A.S.T.M. Designation: A 89) of the American Society for Testing Materials[3] also cover suitable material.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

Manganese, per cent	0.35 to 0.60
Phosphorus, maximum, per cent	0.06
Sulfur, maximum, per cent	0.05

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 122.

[3] *Ibid.*, p. 127.

5. (*a*) Analyses of two pipe from each lot of 100 lengths or fraction thereof may be made by the purchaser of the finished pipe. By agreement between the manufacturer and the purchaser, the analysis may be made on the skelp and the number shall be determined in the same manner as when taken from the finished pipe. **Check Analyses.**

(*b*) *Retests.*—If the analysis of either length of pipe or length of skelp does not conform to the requirements specified in Section 3, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties: **Tension Tests.**

	GRADE A	GRADE B
Tensile strength, lb. per sq. in......	45 000	50 000
Yield point, lb. per sq. in..........	0.5 tens. str.	0.5 tens. str.
but in no case less than..........	24 000	27 000
Elongation in 8 in., per cent........	28	25

(*b*) The yield point shall be determined by the drop of the beam of the testing machine or other approved method.

(*c*) The tensile strength across the weld shall be not less than 95 per cent of the minimum tensile strength specified for the pipe in Paragraph (*a*).

7. If required by the purchaser, the test specimen taken across the weld shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to 4½ times the thickness of the plate without developing cracks. In making the bend test, the side of the specimen representing the inside of the pipe shall be placed next the pin. **Bend Tests.**

8. (*a*) Pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula: **Hydrostatic Tests.**

$$P = \frac{2\,St}{D}$$

where P = the hydrostatic test pressure in pounds per square inch;
S = the allowable fiber stress: 14,000 to 16,000 lb., per sq. in. for Grade A; 16,000 to 18,000 lb. per sq. in. for Grade B. The stress produced shall be not more than 80 per cent of the specified yield point;
t = the wall thickness in inches; and
D = the outside diameter in inches.

(*b*) The hydrostatic pressure shall be maintained for not less than 5 seconds and, while under test pressure, the pipe shall be jarred near both ends with a 2-lb. hammer or its equivalent.

Test Specimens. 9. (*a*) Longitudinal tension test specimens shall be taken from the end of the pipe or skelp at a point approximately 90 deg. from the weld and shall not be flattened between gage marks. Transverse tension test specimens, when required by the purchaser, shall be taken across the weld. The sides of the specimen shall be parallel between gage marks. When impracticable to pull a test specimen in full thickness the A.S.T.M. standard 2-in. gage length test specimen may be used. By agreement between the manufacturer and the purchaser the longitudinal tension test specimen may be taken from the skelp.

(*b*) All specimens shall be tested at room temperature.

(*c*) The openings resulting from the removal of test specimens shall be patched in a manner approved by the purchaser.

Number of Tests. 10. (*a*) One longitudinal tension test and, if requested by the purchaser, one transverse tension test and one bend test shall be made on one length from each lot of 200 lengths or fraction thereof of each size 14 in. up to 20 in. and on one length from each lot of 100 lengths of fraction thereof of each size 21 to 30 in. The number of tests on sizes over 30 in. and up to 96 in. shall be arranged by agreement with the purchaser. When taken from the skelp the number of tests shall be determined in the same manner as when taken from the finished pipe.

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 8.

Retests. 11. (*a*) If the results of the tension or bend tests of any lot do not conform to the requirements specified in Sections 6 and 7, two retests for each failure shall be made from separate lengths of the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length of an 8-in. specimen, as indicated by the scribe scratches marked on the specimen before testing, the specimen may be discarded and another substituted.

(*c*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Permissible Variations. 12. (*a*) *Weight.*—Tolerances on theoretical weights of pipe shall be governed by the weight tolerances for plates as covered in specifications of the American Society for Testing Materials to which the plates are ordered.

(*b*) *Diameter.*—The outside diameter of the pipe shall be within tolerances consistent with the method of field joints. When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall be not more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter. On sizes over 30 in. the permissible variation in diameter shall be set by agreement with purchaser.

(*c*) *Thickness.*—The minimum wall thickness at any point shall be not more than 12.5 per cent under the wall thickness specified.

Lengths.

13. When pipe is ordered in random lengths with plain ends, lengths of 20 ft. with a variation of ± 1 ft. may be furnished. When pipe is ordered to a specified length the tolerance shall be ± $\frac{1}{8}$ in. When pipe with special formed ends is ordered cut to length the tolerance shall be as agreed upon between the manufacturer and the purchaser.

WORKMANSHIP AND FINISH

Workmanship and Finish.

14. The finished pipe shall be reasonably straight, sized at the ends as required and free from injurious defects.

Repairing Defects.

15. (*a*) The welding of injurious defects in the pipe wall will be permitted provided their depth does not exceed one-third the specified wall thickness. Defects in the welds such as sweats or leaks, unless otherwise specified, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity, and then welding.

(*b*) All repaired pipe shall be retested hydrostatically in accordance with Section 8.

MARKING

Marking.

16. Each length of pipe shall be marked with appropriate symbols by stenciling, stamping or rolling to show by whom manufactured and that it conforms to these specifications.

PROTECTIVE COATING

Protective Coating.

17. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall then be given a protective coating of the kind and in the manner specified by the purchaser.

INSPECTION AND REJECTION

Inspection. 18. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to the shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
LOCK-BAR STEEL PIPE[1]

A.S.T.M. Designation: A 137 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover pipe, suitable for conveying liquids or gases, made from steel plates rolled or formed into a circle, having longitudinal edges planed and upset to a dove-tail form which engages in the groove of an "H-shape" steel lock-bar to form the longitudinal joint of the pipe. After assembly of the plates and the lock-bars the latter are closed by cold-pressing, thus making a tight fit over the dove-tail edges of the plates.

MATERIAL

Plates. 2. Unless otherwise specified, the steel plate shall conform to the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials[2] and shall be ordered to thickness.

Lock-Bars. 3. Lock-bars shall be of open-hearth, extra-dead-soft steel conforming to the following chemical and physical requirements:

CHEMICAL COMPOSITION

Phosphorus, maximum, per cent	0.04
Sulfur, maximum, per cent	0.05

PHYSICAL PROPERTIES

Tensile strength, lb. per sq. in.	40 000 to 50 000
Yield point,[a] minimum, lb. per sq. in.	0.5 tens. str.
Elongation in 8 in., minimum, per cent	28
Reduction of area, minimum, per cent	50
Cold bend test	180 deg. flat on itself without sign of fracture on outside of bent portion

[a] Yield point shall be determined by the drop of the beam of the testing machine.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

Rivets.

4. Unless otherwise specified, rivets shall be of the button-head type and shall conform to the requirements of the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.[1]

MANUFACTURE

Ends.

5. (*a*) Rivet holes in the ends of plates may be punched or drilled at the option of the manufacturer.

(*b*) Ends of plates shall be bevel-sheared to an angle of approximately 20 deg. to form caulking edges for the circular joints.

Upsetting of Edges.

6. The longitudinal edges of the plates shall be planed and then upset to a dove-tail form of uniform section, the wide part of which shall fit neatly into the groove of the lock-bar. Any plates splitting or otherwise showing laminations on the edges during the upsetting shall be rejected.

Forming.

7. After upsetting, the longitudinal edges of the plates shall be crimped cold to the form of the finished pipe and the plates shall then be formed throughout their remaining width by cold rolling. During both operations care shall be exercised so that the dove-tail forms on the plate edges are not injured or deformed.

Pipe Assembly.

8. (*a*) In assembling the plates and lock-bars into the form of complete pipe sections, the jaws of the grooves in the lock-bars shall be closed over the dove-tail upset edges of the plates by a press with sufficient power to make the longitudinal joints of the pipe water tight and of a strength equal to that of the plate.

(*b*) The lock-bars of pipe intended for the transportation of gas shall be lightly caulked along each edge.

Condition of Lock-Bars.

9. (*a*) Hair line cracking of the surface of the lock-bars shall be permissible provided individual cracks are not over 3 ft. in length or $\frac{1}{16}$ in. in depth. Depth of cracks may be determined by chipping lengthwise of the crack with a flat chisel, taking off successive thin layers until bottom of the crack is reached.

(*b*) Where pipe is intended for lapped field joints or when flanges, bead bands or other attachment fitting into or over the end of the pipe are to be used, the lock-bar shall be scarfed off to about $\frac{1}{8}$ in. in thickness on the faying side of the pipe to permit the making of the lap joint.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 118.

Lap for Field Joints.

10. (*a*) The lap of a field joint or the distance the small end enters the large end of a pipe shall depend upon the thickness and shall conform to the following requirements:

Pipe Thickness, in.	Width of Lap, in.
3/16	1 7/8
1/4	2 1/4
5/16	2 5/8
3/8	2 7/8
7/16	3 1/4
1/2	3 1/2

(*b*) The edge distance shall be one-half the lap.

Rivets for Field Joints

11. Field joints shall be single riveted unless otherwise specified. The number of rivets per joint shall be an even multiple of four and they shall be so located that one rivet passes through the center of each lock-bar. The diameter of rivets for field joints shall be equal to twice the thickness of the plate plus 1/8 in. except that 1-in. rivets shall be used for 1/2-in. plate. For the different sizes of pipe the number of rivets in single-riveted circular seams shall conform to the requirements specified in Table I.

Table I.—Number of Rivets in Single Riveted Circular Seams.

Thickness of Plate, in.	3/16	1/4	5/16	3/8	7/16	1/2	Thickness of Plate, in.	3/16	1/4	5/16	3/8	7/16	1/2
Diameter of Rivets, in.	1/2	5/8	3/4	7/8	1	1	Diameter of Rivets, in.	1/2	5/8	3/4	7/8	1	1
Outside Diameter of Pipe, in.	Number of Rivets						Outside Diameter of Pipe, in.	Number of Rivets					
20	40	32	28	28	24	24	45	88	76	68	60	56	56
21	40	36	32	28	24	28	46	88	80	68	60	56	60
22	44	36	32	28	28	28	47	92	80	72	64	56	60
23	44	40	36	32	28	28	48	92	80	72	64	60	60
24	48	40	36	32	28	32	49	96	84	72	64	60	64
25	48	40	36	32	28	32	50	96	84	76	68	60	64
26	52	44	40	36	32	32	51	100	88	76	68	60	64
27	52	46	40	36	32	36	52	100	88	80	68	64	68
28	56	46	40	36	32	36	53	104	92	80	72	64	68
29	56	48	44	40	36	36	54	104	92	80	72	64	68
30	60	52	44	40	36	40	55	108	92	84	72	68	72
31	60	52	48	40	36	40	56	108	96	84	76	68	72
32	60	52	48	44	40	40	57	112	96	84	76	68	72
33	64	56	48	44	40	40	58	112	100	88	76	72	76
34	64	56	52	44	40	44	59	116	100	88	80	72	76
35	68	60	52	48	44	44	60	116	100	88	80	72	76
36	68	60	52	48	44	44	61	120	104	92	80	76	80
37	72	64	56	48	44	48	62	120	104	92	84	76	80
38	72	64	56	52	44	48	63	124	108	96	84	76	80
39	76	64	60	52	48	48	64	124	108	96	84	76	84
40	76	68	60	52	48	52	65	128	108	96	88	80	84
41	80	68	60	56	48	52	66	128	112	100	88	80	84
42	80	72	64	56	52	52	67	132	112	100	88	80	84
43	84	72	64	56	52	56	68	132	116	104	92	84	88
44	84	76	68	60	52	56	69	136	116	104	92	84	88
							70	136	120	104	96	84	88
							71	140	120	108	96	88	92
							72	140	120	108	96	88	92

HYDROSTATIC TESTS

Hydrostatic Tests.

12. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula, provided that in no case shall the test pressure exceed 500 lb.:

$$P = \frac{2\,St}{D}$$

where P = the hydrostatic pressure in pounds per square inch;
S = the allowable fiber stress (maximum 20,000 lb. per sq. in.);
t = the wall thickness in inches; and
D = the outside diameter in inches.

(*b*) While under test pressure, the lock-bars shall be struck at intervals of 5 to 6 ft. with full arm swing of a 10-lb. maul. In general, there shall be no seepage of water at the lock-bar joints but occasional slight weeping may be stopped by light caulking of the edge of the lock-bar.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Diameter.

13. The outside diameter of the pipe shall be within tolerances consistent with the method of field joints. When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe, and shall permit the passing, for the distance of 8 in., of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.

Thickness.

14. Unless otherwise provided for in the contract, the purchaser shall specify the wall thickness. The strength of the lock-bar longitudinal joint shall be assumed as 100 per cent.

Length.

15. Unless otherwise specified, the standard length shall be not less than 30 ft.

PROTECTIVE COATING

Protective Coating.

16. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating of the kind and in the manner specified by the purchaser.

PACKING

Packing.

17. After the pipe has been coated, it shall be handled carefully in such manner as will not injure or mar the coating and so loaded on cars or trucks as to prevent contact of pipe with other pipe or with stakes or saddles. Burlap pads or other approved materials shall be used to prevent injury to the coating and shall be well secured to prevent shifting in transportation.

INSPECTION AND REJECTION

18. The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

TENTATIVE SPECIFICATIONS
FOR
RIVETED STEEL AND WROUGHT-IRON PIPE[1]

A.S.T.M. Designation: A 138 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. These specifications cover shop-fabricated straight pipe, suitable for conveying liquids or gases, made from steel or wrought-iron plates with riveted seams.

MATERIAL

Plates. 2. (*a*) Unless otherwise specified, the steel plate shall be of open-hearth steel, conforming to the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials,[2] and shall be ordered to thickness.

(*b*) If wrought-iron plates are specified they shall conform to the Standard Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42) of the American Society for Testing Materials.[3]

Rivets. 3. Unless otherwise specified, rivets for steel pipe shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.[4] Unless otherwise specified, rivets for wrought-iron pipe shall be of wrought iron.[a]

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[a] Pending the development by Committee A-2 on Wrought Iron of specifications for wrought-iron rivets, it is recommended that rivet material shall conform to Grade B of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A.S.T.M. Designation: A 84) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part I, p. 435.

MANUFACTURE

Type of Joint. 4. (*a*) Standard pipe shall be made of in-and-out courses, unless tapered courses are specified by the purchaser.

(*b*) Edges of plates less than $\frac{5}{8}$ in. in thickness which are to be caulked shall be beveled.

(*c*) At the junction of longitudinal and circular joints, the middle plate shall be properly scarfed.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

[3] *Ibid.*, p. 452.

[4] *Ibid.*, p. 118.

Rivet Holes.

5. (*a*) All rivet holes for butt-joint pipe and for lap-joint pipe, where the plate thickness exceeds $\frac{1}{2}$ in. shall be sub-punched $\frac{1}{8}$ in. smaller and reamed to size or drilled full size. The diameter of the finished rivet hole shall be $\frac{1}{16}$ in. greater than the specified diameter of the rivet.

(*b*) The diameter of the die shall not exceed the diameter of the punch by more than $\frac{1}{16}$ in. All burrs shall be removed. Punched holes shall be spaced true to line, so that when the plates are brought together the holes will match properly.

(*c*) A sufficient number of rivet pass-holes shall be provided at convenient places and shall be equipped with proper size plugs for closing the same.

(*d*) Drift pins may be used only for drawing the material together. Their use to enlarge unfair holes will not be permitted. Necessary corrections to ensure matching of holes shall be made with a reamer.

Forming

6. All plates shall be formed cold to as nearly a true circle as practicable.

Pipe Assembly.

7. (*a*) *Riveting.*—All rivets shall be machine driven, either by hydraulic or pneumatic riveting machines, exerting a slow steady pressure sufficient to form a strong and tight rivet joint. All rivets after being driven shall completely fill the hole and shall have full heads concentric with the shank. All loose, burned, or otherwise defective rivets shall be cut out and replaced. Care shall be exercised not to damage the adjacent material when cutting out rivets.

(*b*) *Caulking.*—Unless otherwise specified, all straight pipe shall be caulked, both inside and outside. All caulking shall be done with a round-nosed tool. No split caulking shall be permitted. When so specified, the joints may be made tight by welding instead of caulking.

HYDROSTATIC TESTS

Hydrostatic Tests.

8. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D} \times e$$

where P = the hydrostatic pressure in pounds per square inch;

S = the allowable fiber stress, which shall not exceed 20,000 lb. per sq. in. for steel pipe nor more than 13,000 lb. per sq. in. for wrought-iron pipe;

t = the wall thickness in inches;

D = the outside diameter in inches; and

e = the efficiency of the joint, in accordance with Paragraph U-20 of the Rules for Unfired Pressure Vessels of the A.S.M.E. Boiler Construction Code.

(*b*) All leaks shall be made tight under test. Sweating of rivets and seams under pressure shall not be considered leaks.

DIMENSIONS

Length. 9. Unless otherwise specified, pipe shall be fabricated in shipping lengths of 30 ft. or over, but each length shall be made of not more than four courses.

PROTECTIVE COATING

Protective Coating. 10. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating of the kind and in the manner specified by the purchaser.

INSPECTION AND REJECTION

Inspection. 11. The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 12. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL TELEPHONE AND TELEGRAPH LINE WIRE[1]

A.S.T.M. Designation: A 111 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover galvanized iron or steel wire suitable for use in telephone, telegraph and signal transmission where electrical characteristics of the wire are important.

MANUFACTURE

Zinc Coating. 2. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2]

Base Metal. 3. (*a*) The base metal shall be iron or steel of such quality and purity that when drawn, uniformly annealed and galvanized, the finished wire will have the properties herein specified for its size and grade.

(*b*) If copper-bearing base metal is desired, the copper content shall conform to the following requirements:

Copper, minimum, per cent	Ladle analysis	0.20
	Check analysis	0.18

Joints. 4. (*a*) Wire 0.134 in. or under in diameter shall be furnished in coils of one continuous length without factory joints. Wire 0.148 in. or over in diameter shall preferably be furnished without factory joints; however, not more than 10 per cent of the coils in any lot of wire 0.148 in. or over in diameter offered for inspection may contain one joint per coil.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

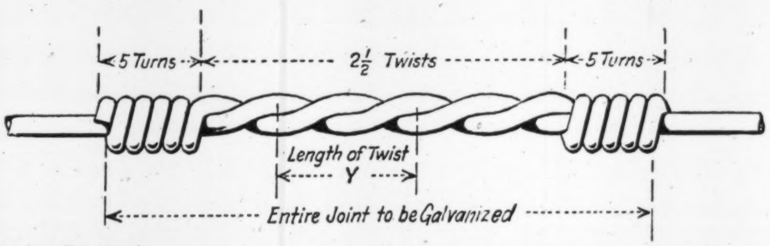
These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A.S.T.M. Designation: A 111 – 30), 1930 Book of A.S.T.M. Standards, Part I, p. 294.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

(*b*) Joints in the wire shall be made in accordance with the sketch shown in Fig. 1 and, after the joint is made, shall be protected by galvanizing as are the other portions of the wire.

SAMPLING

Sampling for Tests. 5. The inspector shall select at random during the visual examination specified in Section 20, 1 sample coil from every 10 coils in the lot, but not less than 3 coils from the entire lot. From each coil thus selected 1 sample of suitable length shall be taken for each of the weight of coating, uniformity of coating, physical and electrical tests of coating and wire as specified in Sections 6 to 13, inclusive.



Nominal Diameter of Galvanized Wire, in.	Size, B.w.g.[a]	Distance "Y"
0.238	4	1¾ in.
0.203	6	1½ in.
0.165	8	1¼ in.
0.148	9	1 in.

[a] B.w.g. is standard gage for this type of wire.

FIG. 1.—Standard Line Wire Joint.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating. 6. The weight of zinc coating for wires 0.109 in. in diameter and larger shall be not less than 0.8 oz. per sq. ft. of uncoated wire surface. The weight of coating for wire 0.083 in. in diameter shall be not less than 0.7 oz. per sq. ft. of uncoated wire surface.

Weight of Coating Test. 7. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1]

Uniformity of Coating. 8. The uniformity of the zinc coating shall be determined by the Preece test as described in the appendix to the Standard Methods for

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1] This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to the requirements of Sections 6 and 7. Coatings for wires 0.109 in. in diameter or larger shall stand without failure 4 dips of 1 minute each; coatings on wires 0.083 in. in diameter shall stand without failure 3 dips of 1 minute each and 1 dip of 30 seconds.

Adherence of Coating.

9. (*a*) The zinc coating shall remain adherent when the wire is wrapped at a rate of not more than 15 turns per minute in a closed helix at least twice around a cylindrical mandrel of the diameter specified. The mandrel diameter shall be approximately an even multiple of the diameter of wire tested. The mandrel shall be specified by the number corresponding to this diameter ratio. For example, mandrel No. 1 and mandrel No. 12 designate mandrel diameters respectively one and twelve times the wire diameter.[2]

(*b*) The zinc coating shall adhere firmly to the wire and shall be considered as meeting this requirement if, due to wrapping about the specified mandrel it does not flake and none of the coating can be removed from the wire by rubbing with the bare fingers.

PHYSICAL PROPERTIES AND TESTS

Tensile Strength.

10. The tensile strength of the galvanized wire shall be not less than the value specified for its size and grade in Table I.

TABLE I.—TENSILE STRENGTHS.

Nominal Diameter of Galvanized Wire, in.	Size, B.w.g.	Minimum Tensile Strength, lb.		
		Grade EBB	Grade BB	Grade Steel
0.238	4	2028	2270	2433
0.203	6	1475	1650	1770
0.165	8	975	1090	1170
0.148	9	785	880	942
0.134	10	645	720	774
0.120	11	515	575	618
0.109	12	425	475	510
0.083	14	247	275	297

Elongation.

11. The galvanized wire shall have an elongation of not less than 10 per cent in 10 in. The elongation shall be determined as the permanent increase in length after failure of a marked section of the wire originally 10 in. in length.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 390.

[2] The coatings on all commercially available wire manufactured to meet these specifications will pass a wrap test on mandrel No. 12. Coatings are available passing wrap tests on mandrels as small as No. 1. Coatings passing wrap tests on mandrels of intermediate sizes may be specified.

Twists. 12. The galvanized wire shall stand without fracture not less than 35 twists in a length equivalent to 100 diameters. This test shall be made in a standard torsion machine or equivalent, with one head of the machine rotating and the opposite head non-rotating but movable horizontally. The weight on the movable head shall be 15 lb. and the rate of rotation 35 twists in 2 minutes.

ELECTRICAL PROPERTIES

Resistivity. 13. The resistivity of the wire expressed in pounds per mile-ohm (weight of wire of uniform diameter yielding a resistance of one ohm per mile length) at 20° C. (68° F.) shall conform to the requirements given in Table II.

TABLE II.—RESISTIVITY, LB. PER MILE-OHM.

	GRADE EBB		GRADE BB		GRADE STEEL	
	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM
Copper-bearing......	5000	5200	5600	5800	6500	6800
Non-copper-bearing..	4800	5000	5400	5600	6300	6600

The values given as average in the table shall not be exceeded by the average of all results determined for the lot of wire. Individual samples may have resistivities not exceeding the values given as maximum

SIZE AND PERMISSIBLE VARIATIONS

Size. 14. (*a*) The size of the galvanized wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

Permissible Variations. (*b*) The permissible variations of the galvanized wire from the nominal diameter shall be:

For wire 0.109 in. or larger in diameter	±0.004 in.
For wire smaller than 0.109 in. in diameter.............	±0.003 in.

Gaging. (*c*) The wire of each coil selected for purpose of test (see Section 20) shall be gaged in three places; one near each end of the coil and one approximately at the middle.

(*d*) A coil shall be rejected if the gage at any point is not within the limits specified in Paragraph (*b*).

WORKMANSHIP AND FINISH

Finish. 15. The galvanized wire shall be free from splints, scales, inequalities, flaws and other imperfections not consistent with good commercial practice. The zinc coating shall be smooth and continuous.

PACKING AND MARKING

Packing. 16. (*a*) The finished wire shall be furnished in compact coils reasonably symmetrical in shape. The diameter of the eye of each coil shall not be less than 20 nor more than 22 in., except that in the case of wire 0.203 in. or larger in diameter, the maximum diameter of the eye may be 24 in.

Coil Lengths. (*b*) The length of wire in each coil shall conform approximately to the value given in Table III. The weight of any coil shall not vary by more than 10 per cent from the specified weight.

TABLE III.—MINIMUM AMOUNT OF WIRE IN EACH COIL.

NOMINAL DIAMETER OF GALVANIZED WIRE, IN.	SIZE, B.W.G.	AMOUNT OF WIRE IN COIL LENGTH	WEIGHT
0.238	4	¼ mile or	197 lb.
0.203	6	⅓ mile or	191 lb.
0.165	8	½ mile or	189 lb.
0.148	9	½ mile or	152 lb.
0.134	10	½ mile or	126 lb.
0.120	11	½ mile or	100 lb.
0.109	12	½ mile or	82 lb.
0.083	14	½ mile or	48 lb.

(*c*) Each coil shall be securely bound in four separate places, equally spaced, with at least two wrappings of galvanized wire, not smaller than 0.109 in. in diameter. The outer end of each coil shall be bent back over the binding wire to prevent it from crowding into the coil.

Marking. 17. To each coil shall be securely wired a metal tag showing the size and kind of wire, weight of coil, and the manufacturer's name or mark.

ORDERING

Orders. 18. Orders for wire under these specifications shall include the following:

Size (in decimal fraction of an inch);
Copper-bearing (if addition of copper to the base metal is desired);
Grade (EBB, BB, or Steel); and
Mandrel test for zinc coating (mandrel 1 to mandrel 12 as desired).

NOTE.—*Example.*—A typical order, including the necessary information to guide the manufacturer, is as follows:

5000 lb. 0.109-in. copper-bearing galvanized BB wire, mandrel 5, A.S.T.M. Specifications A 111 – 32 T.

INSPECTION AND REJECTION

Inspection. 19. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 20. The inspector shall visually examine the entire shipment or lot of coils for surface imperfections. If, after visual examination, more than 3 per cent of the coils in the entire lot are found defective, the purchaser may reject the entire lot. If the visual tests are satisfactory one third of the coils shall then be examined to determine whether the diameter is within the limits specified in Section 14 (*c*). If more than 3 per cent of these coils do not conform to the requirements for the diameter, the purchaser may reject the entire lot. If more than 3 per cent of the samples selected in accordance with Section 5, fail to pass any of the tests specified in Sections 6 to 13, inclusive, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the coils from which the original non-conforming samples were taken, shall be cut and tested for the non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL TIE WIRES[1]

A.S.T.M. Designation: A 112 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

1. These specifications cover galvanized iron or steel tie wires for use in tying galvanized telephone and telegraph line wire to insulators. **Scope.**

MANUFACTURE

2. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2] **Zinc Coating.**

3. (*a*) The base metal shall be iron or steel of such quality and purity that when drawn, uniformly annealed and galvanized, the tie wires will have the properties herein specified for their size. **Base Metal.**

(*b*) If copper-bearing base metal is desired, the copper content shall conform to the following requirements:

Copper, minimum, per cent	Ladle analysis	0.20
	Check analysis	0.18

4. There shall be no joints in tie wires. **Joints.**

SAMPLING

5. The inspector shall select at random during the visual examination, specified in Section 21, 1 sample bundle from every 10 bundles in the lot, but not less than 3 bundles from the entire lot. From each **Sampling for Tests.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A.S.T.M. Designation: A 112 – 30), 1930 Book of A.S.T.M. Standards, Part I, p. 299.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

bundle thus selected 1 sample tie wire shall be taken for each of the weight of coating, uniformity of coating and physical tests of coating and wire as specified in Sections 6 to 12, inclusive.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating. 6. The weight of zinc coating for tie wires 0.109 in. in diameter and larger shall be not less than 0.8 oz. per sq. ft. of uncoated wire surface. The weight of coating for tie wires 0.083 in. in diameter shall be not less than 0.7 oz. per sq. ft. of uncoated wire surface.

Weight of Coating Test. 7. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1]

Uniformity of Coating. 8. The uniformity of the zinc coating shall be determined by the Preece test, as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[2] This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to the requirements of Sections 6 and 7. Coatings for wires 0.109 in. in diameter or larger shall stand without failure 4 dips of 1 minute each; coatings on wires 0.083 in. in diameter shall stand without failure 3 dips of 1 minute each and 1 dip of 30 seconds.

Adherence of Coating. 9. (*a*) The zinc coating shall remain adherent when the tie wire is wrapped at a rate of not more than 15 turns per minute in a closed helix at least twice about a cylindrical mandrel having a diameter equivalent to the nominal diameter of the tie wire under test.

(*b*) The zinc coating shall adhere firmly to the wire and shall be considered as meeting this requirement if, due to wrapping about the mandrel, it does not flake and none of the coating can be removed from the wire by rubbing with the bare fingers.

PHYSICAL PROPERTIES AND TESTS

Tensile Strength. 10. The average tensile strength of the tie wires shall not exceed 60,000 lb. per sq. in. and no individual sample shall exceed 63,000 lb. per sq. in.

Elongation. 11. The galvanized tie wires shall have an elongation of not less than 12 per cent in 10 in. The elongation shall be determined as the permanent increase in length after failure of a marked section of the wire originally 10 in. in length.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

[2] *Ibid.*, p. 390.

12. The galvanized tie wires shall stand without fracture not less than 35 twists in a length equivalent to 100 diameters. This test shall be made in a standard torsion machine or equivalent, with one head of the machine rotating and the opposite head non-rotating but movable horizontally. The weight on the movable head shall be 15 lb., and the rate of rotation 35 twists in 2 minutes. **Twists.**

SIZE AND PERMISSIBLE VARIATIONS

13. (*a*) The size of the galvanized tie wire shall be expressed as the diameter of the wire in decimal fractions of an inch. The sizes of tie wires shall be as follows: **Size.**

NOMINAL DIAMETER OF GALVANIZED WIRE, IN.	SIZE, B. w. g.[a]
0.165	8
0.148	9
0.134	10
0.109	12
0.083	14

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[a] B. w. g. is standard gage for this type wire.

(*b*) The permissible variations of the galvanized wire from the nominal diameter shall be: **Permissible Variations.**

For wire 0.109 in. or over in diameter	±0.004 in.
For wire under 0.109 in. in diameter	±0.003 in.

14. Three tie wires from each test bundle (see Section 21) shall each be gaged in at least three separate places. The bundle shall be rejected if the average gage is not within the limits specified in Section 13 (*b*). **Gaging.**

15. The length of the tie wires shall not vary more than ± $\frac{1}{8}$ in. from the length specified in the order. **Length.**

WORKMANSHIP AND FINISH

16. The galvanized tie wires shall be free from splints, scales, flaws, and other imperfections not consistent with good commercial practice. The zinc coating shall be smooth and continuous. The ends of the tie wires need not be galvanized. **Finish.**

17. The tie wires shall be smoothly cut. All tie wires shall be free from ragged, sharp or chisel-shaped ends. **Cutting.**

PACKING AND MARKING

18. (*a*) Tie wires shall be packed in bundles of the weight specified, but in no case shall bundles exceed 50 lb. in weight. **Packing.**

(*b*) Each bundle shall be bound at the middle with galvanized wire and then wrapped with burlap or heavy paper and bound near each end with the same kind of wire used for the inner binding.

Marking. 19. To each bundle shall be securely fastened a strong tag showing the size of the galvanized tie wire, gross weight, specified length, and the manufacturer's name or mark.

INSPECTION AND REJECTION

Inspection. 20. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 21. The inspector shall visually examine the entire shipment or lot of bundles for surface imperfections. If, after visual examination, over 3 per cent of the bundles in the entire lot are found defective, the purchaser may reject the entire lot. If the visual tests are satisfactory, one-third of the bundles shall then be tested for size and length in accordance with Sections 13, 14 and 15. If over 3 per cent of these bundles do not conform to the requirements for the diameter and length, the purchaser may reject the entire lot. If more than 3 per cent of the samples selected in accordance with Section 5, fail to pass any of the tests specified in Sections 6 to 12, inclusive, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the bundles from which the original non-conforming samples were taken, shall be selected and tested for the non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL FARM-FIELD AND RAILROAD RIGHT-OF-WAY WIRE FENCING[1]

A.S.T.M. Designation: A 116 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover galvanized iron or steel wire fencing of the following commercial types; farm-field fencing and railroad right-of-way fencing.

Basis of Purchase. 2. All rolls of fencing accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the rolls before sampling.

MANUFACTURE

Style and Size. 3. It is recommended that styles and sizes of fence fabrics covered by these specifications be in accordance with those recommended by the U. S. Department of Commerce in its Simplified Practice Recommendation No. 9–28 Woven-Wire Fencing; Woven-Wire Fence Packages or its subsequent recommendations.

Zinc Coating. 4. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2]

Base Metal. 5. (*a*) The base metal of the fabric shall be a good commercial quality of steel or iron wire.

(*b*) If copper-bearing base metal is desired, the copper content shall conform to the following requirements:

Copper, minimum, per cent	Ladle analysis	0.20
	Check analysis	0.18

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A.S.T.M. Designation: A 116 - 30), 1930 Book of A.S.T.M. Standards, Part I, p. 302.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

SAMPLING

Sampling.

6. For purpose of tests, 1 roll from each 20 rolls of fencing, but not less than 3 rolls of each lot, shall be taken for a sample. Sufficient length of the fencing shall be cut from the end of the roll to include three stay wires. The test specimens for the line wire shall be cut between these three stays. The test specimens for the stays shall be cut from two of these three stays. All wire knots, wraps or welds shall be excluded from the test. The resultant specimens of the line and stay wire from each sample roll shall be put into separate groups. Three specimens from each of these groups shall be subjected to the test for the weight of coating in accordance with Sections 7 and 8, and three specimens from each of these groups shall be subjected to the test for uniformity of coating, in accordance with Section 9.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating.

7. (*a*) *Zinc-Coated* (*Galvanized*) *Farm-Field Wire Fencing.*—The weight of zinc coating on any individual wire of the completed fence shall be not less than that specified by the purchaser. Weight of coating commercially available on the various gages of wire used is indicated opposite the nominal diameter in Table I.

TABLE I.—ZINC-COATED FARM-FIELD WIRE FENCING.

NOMINAL DIAMETER OF GALVANIZED WIRE, IN.	SIZE, STEEL WIRE GAGE[a]	MINIMUM WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE
0.192	6	0.40
0.177	7	0.40
0.162	8	0.40
0.148	9	0.40
0.135	10	0.30
0.120	11	0.30
0.105	12	0.30
0.098	12½	0.30

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[a] This is standard gage for this type of wire, and refers to gage of galvanized wire.

NOTE.—By contractual arrangement wire may be obtained carrying coatings of 0.40 oz. per sq. ft. of uncoated wire surface on the smaller gages indicated in the above table.

(*b*) *Zinc-Coated* (*Galvanized*) *Railroad Right-of-Way Wire Fencing.*—The weight of zinc coating on any individual wire of the completed fence shall be not less than that specified by the purchaser. The weight of coating commercially available on the four sizes of wire (0.148, 0.162, 0.177 and 0.192 in. in nominal diameter) generally used in making this type of fence is 0.60 oz. per sq. ft. of uncoated wire surface.

NOTE.—By contractual arrangement, wire may be obtained carrying coatings of 0.60 oz. per sq. ft. of uncoated wire surface on smaller gages than those indicated above.

Weight of Coating Test.

8. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1]

Uniformity of Coating.

9. (*a*) The uniformity of zinc coating shall be determined by the Preece test as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[2] This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to the requirements of Sections 7 and 8.

(*b*) The number of dips that the commercially available weights of coatings on wires of the various diameters will stand without failure, shall conform to the following requirements for the respective type of fence:

Farm-Field Wire Fencing.—Coatings for wires 0.148 in. in diameter and larger shall stand without failure 2 dips of 1 minute each, and 1 dip of 30 seconds; coatings for wires 0.135 to 0.0985 in., inclusive, in diameter shall stand without failure 1 dip of 1 minute and 1 dip of 30 seconds.

Railroad Right-of-Way Wire Fencing.—Coatings for the four sizes of wire designated in Section 7 (*b*) shall stand without failure 4 dips of 1 minute each.

SIZE AND PERMISSIBLE VARIATIONS

Size.

10. (*a*) The size of the galvanized wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

(*b*) The permissible variations of the galvanized wire from the nominal diameter shall be:

For wire, 0.109 in. or over in diameter	±0.004 in.
For wire, under 0.109 in. in diameter	±0.003 in.

PACKING AND MARKING

Packing and Marking.

11. Each length of fencing shall be tightly rolled and firmly tied. For ease of handling, consideration shall be given to the weight of

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

[2] *Ibid.*, p. 390.

the roll, depending upon the length of fencing. Each roll of fencing shall carry a tag legibly marked as specified by the purchaser.

INSPECTION AND REJECTION

Inspection. 12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. If 20 per cent of the specimens tested by the weight of coating test, or the uniformity of coating test, fail to conform to the requirements of these specifications, additional specimens shall be selected as described in Section 6, and a retest for the non-conforming properties shall be made; and if 20 per cent of these specimens fail, the entire lot thus inspected may be rejected.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED IRON OR STEEL CHAIN-LINK FENCE FABRIC GALVANIZED AFTER WEAVING[1]

A.S.T.M. Designation: A 117 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover zinc-coated chain-link fence fabric, galvanized after weaving, in which the individual pickets are helically wound and interwoven in the form of a continuous link fabric without knots or ties.

Size and Mesh. 2. These specifications cover the usual sizes of wire and mesh as follows:

NOMINAL DIAMETER OF UNCOATED WIRE, IN.	SIZE, UNCOATED WIRE GAGE	SIZE OF MESH, IN.	HEIGHT OF FENCE FABRIC, IN.
0.192.........	6	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.148.........	9	2	36, 42, 48, 60, 72, 84, 96, 108, 120, 144
0.120.........	11	2	36, 42, 48, 60, 72, 84, ...
0.120.........	11	$1\frac{3}{4}$	.. .. 96, 108, 120, 144

Basis of Purchase. 3. All rolls of fencing accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the rolls before sampling, unless changed by contractual arrangement.

MANUFACTURE

Weave. 4. The wire shall be woven throughout in the form of approximately uniform square mesh, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions. The top and bottom of the fabric shall be knuckled or barbed as specified. The fencing shall be galvanized after weaving.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated Iron or Steel Chain-Link Fabric Galvanized After Weaving (A.S.T.M. Designation: A 117 – 30), 1930 Book of A.S.T.M. Standards, Part I, p. 305.

Zinc Coating.

5. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[1]

Base Metal.

6. (*a*) The base metal of the fabric shall be a good commercial quality of steel or iron wire.

(*b*) If copper-bearing base metal is desired, the copper content shall conform to the following requirements:

Copper, minimum, per cent..........	Ladle analysis.........	0.20
	Check analysis........	0.18

SAMPLING

Sampling.

7. (*a*) *Samples.*—For the purpose of tests, 1 roll for each 10 per cent of the rolls of fabric in shipments of less than 50 rolls shall be taken as a sample. One roll representing each 5 per cent of the rolls in shipments of over 50 rolls shall be taken as a sample. In no case shall there be less than three samples taken.

(*b*) *Test Specimens.*—Specimens for testing shall consist of 1 sq. ft. of woven fencing selected at any point in the width of the fence fabric, exclusive of the twisted or knuckled portions, and taken from the end of the roll. A specimen from each sample shall be subjected to the test for the weight of coating in accordance with Section 8, and a specimen from each sample shall be subjected to the test for uniformity of coating in accordance with Section 10.

(*c*) *Calculation of Surface Area.*—By means of the following formulas, the wire surface area in square feet contained in 1 sq. ft. of fabric can be calculated to facilitate the computation of the surface area of the specimens:

Square feet of wire surface of Size 6 (Steel Wire Gage) wire $= 0.516W$
" " " " " " " 9 (" " ") " $= 0.674W$
" " " " " " " 11 (" " ") " $= 0.830W$

where W is the weight in pounds of wire in 1 sq. ft. of fabric after being stripped of galvanizing.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating.

8. The weight of zinc coating on the wire shall be not less than 1.2 oz. per sq. ft. of uncoated wire surface.

Weight of Coating Test.

9. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[2]

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

[2] *Ibid.*, p. 385.

Uniformity of Coating. 10. The uniformity of the coating shall be determined by the Preece test as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1] This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to the requirements of Sections 8 and 9. Coatings shall stand without failure 5 dips of 1 minute each.

PACKING AND MARKING

Packing and Marking. 11. The continuous lengths of fence fabric shall be 25, 50, or 100 ft., or as specified. Each length of fabric shall be tightly rolled and firmly tied. For ease of handling, consideration shall be given to the weight of the roll, depending upon the length of fabric. Each roll of fabric shall carry a tag showing the class of coating, the gage of the wire, the length of fencing in the roll, and the manufacturer's name or mark.

INSPECTION AND REJECTION

Inspection. 12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. If any specimen tested fails to meet the requirements of these specifications, two additional specimens shall be cut from the remainder of the sample and tested, both of which shall meet the requirements in every respect or the lot represented by the sample may be rejected.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 390

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL BARB WIRE[1]

A.S.T.M. Designation: A 121 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover galvanized iron or steel barb wire in which the wire is zinc coated before or after fabrication, as herein noted.

Sizes and Constructions. 2. These specifications cover the usual sizes and standard constructions of barb wire as follows:

NOMINAL DIAMETER OF GALVANIZED WIRE IN THE STRAND, IN.	COMMERCIAL DESIGNATION	NUMBER OF BARBS	BARB SPACING, IN.
0.105	Hog	4	4
0.105	Cattle	4	6
0.098	Hog	4	4
0.098	Cattle	4	4
0.098	Hog	2	3
0.098	Cattle	2	5
0.080	Hog	2	3
0.080	Cattle	2	5

Basis of Purchase. 3. All spools of barb wire accepted by the purchaser shall be billed to him on the basis of the original weight or footage of the spools before sampling.

MANUFACTURE

Zinc Coating. 4. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A.S.T.M. Designation: A 121 – 30), 1930 Book of A.S.T.M. Standards, Part I, p. 308.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

Base Metal.

5. (*a*) The base metal of the barb wire shall be a good commercial quality of steel or iron wire.

(*b*) If copper-bearing base metal is desired, the copper content shall conform to the following requirements:

Copper, minimum, per cent	Ladle analysis	0.20
	Check analysis	0.18

Sampling.

6. (*a*) For purpose of tests, one spool shall be selected at random from every 10 spools or fraction thereof in a shipment. Sufficient length of barb wire shall be cut from the end of the roll to include three barbs.

(*b*) In the case of barb wire galvanized before weaving, the barbs shall be cut from the strand and discarded. The strand wires shall be tested separately.

(*c*) Barb wire galvanized after weaving shall be tested as woven with barbs and strand in place.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating.

7. The weight of zinc coating on any individual wire composing the barb wire shall be not less than specified by the purchaser. Weight of coating commercially available on the following wire is 0.30 oz., minimum, per sq. ft. of uncoated wire surface.

NOMINAL DIAMETER OF GALVANIZED WIRE, IN.	GAGE[a]
0.1055	12
0.0985	12½
0.080	14

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[a] Steel wire gage is standard for this type wire and refers to gage of galvanized wire.

NOTE.—By contractual arrangement barb wire galvanized before weaving may be obtained in size 0.098 in. and larger carrying heavier coatings than indicated in Section 7.

By contractual arrangement barb wire galvanized after weaving is available in the above and larger sizes with a coating of 1.0 oz. per sq. ft. of uncoated wire surface.

Weight of Coating Test.

8. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1]

Uniformity of Coating.

9. The uniformity of zinc coating shall be determined by the Preece test as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

Designation: A 90) of the American Society for Testing Materials.[1] This test shall not be used to determine the weight of coating and shall be applied only after the coating has been found to conform to the requirements of Sections 7 and 8.

Coatings for the three sizes of wire designated in Section 7, shall stand without failure 1 dip of 1 minute and 1 dip of 30 seconds.

NOTE.—By contractual arrangement, barb wire galvanized after weaving is available in the above and larger sizes which will stand without failure 4 dips of 1 minute.

SIZE AND PERMISSIBLE VARIATIONS

Size. 10. (*a*) The size of the galvanized wire shall be expressed as the nominal diameter of the wire in decimal fractions of an inch.

Permissible Variations. (*b*) The permissible variations of the galvanized wire from the nominal diameter in barb wire galvanized before weaving shall be ±0.005 in.

PACKING AND MARKING

Packing and Marking. 11. Each spool of barb wire shall be compactly wound and fastened and shall be legibly marked as specified by the purchaser.

INSPECTION AND REJECTION

Inspection. 12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. If 20 per cent of the samples tested fail to conform to the requirements of these specifications, then a check test of these same sample spools shall be made and, if in the check test 20 per cent of the samples fail to conform to the requirements then the entire lot represented by the samples may be rejected.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 390.

TENTATIVE SPECIFICATIONS

FOR

ZINC-COATED (GALVANIZED) IRON OR STEEL WIRE STRAND (CABLE)[1]

A.S.T.M. Designation: A 122 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover galvanized iron or steel wire strand, composed of a multiplicity of wires, and suitable for use as guy wires, messenger wires, span wires, electrical conductors, overhead ground wires, etc.

MANUFACTURE

Zinc Coating. 2. The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[2]

Base Metal. 3. The base metal shall be iron or steel of such quality and purity that, when drawn to the size of wire specified and galvanized, the finished strand and the individual wires will be of uniform quality and have the properties and characteristics herein specified.

Joints. 4. (*a*) There shall be no strand joints or strand splices in any length of the completed strand unless specifically permitted by the purchaser.

The individual wires composing the strand shall, preferably, be of continuous length without factory joints. Factory joints in the individual wires of 19- and 37-wire strand shall be kept well spaced and at a minimum in number. In 7-wire strand, joints in individual wires are acceptable provided there be no more than one joint in any 150-ft. section of the completed strand and the location of each wire joint be marked on the strand with paint or some other distinguishing mark.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted, the present Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (A.S.T.M. Designation: A 122 – 30), 1930 Book of A.S.T.M. Standards, Part I, p. 311.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

(*b*) Joints in the wires composing the strand shall be either the brazed-lap type or butt-welded type. When the brazed type of joint is used, the length of the lap shall be not less than three times the diameter of the wire and the over-lapping faces shall be smooth, clean, properly fluxed and completely covered by the brazing metal. When the butt-welded type of joint is used, care shall be taken to prevent injury to the wire by reason of overheating. All joints shall be well made and shall be galvanized after completion.

Stranding. 5. Unless otherwise specified, 7-wire strand shall have a left-hand lay with a uniform pitch not less than twelve nor more than sixteen times the nominal diameter of the strand. In the case of 19- and 37-wire strand, the outer layer of wires shall be left-hand lay. A left-hand lay is defined as a counter-clockwise twist away from the observer. All wires shall be stranded with uniform tension. Stranding shall be sufficiently close to insure no appreciable reduction in diameter when tested to 10 per cent of the specified strength.

TABLE I.—NOMINAL DIAMETERS AND MINIMUM WEIGHTS OF COATING FOR GALVANIZED STEEL WIRES.

NOMINAL DIAMETER OF GALVANIZED WIRE IN THE STRAND, IN.	"GALVANIZED" COMMON MINIMUM WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE	"EXTRA GALVANIZED" OR "DOUBLE GALVANIZED" COMMON, SIEMENS-MARTIN, HIGH STRENGTH AND EXTRA-HIGH STRENGTH MINIMUM WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE
0.207	0.40	0.90
0.188	0.40	0.90
0.165	0.40	0.80
0.145	0.40	0.80
0.120	0.30	0.80
0.104	0.30	0.80
0.093	0.30	0.70
0.080	0.30	0.60
0.072	0.15	0.50
0.062	0.15	0.50
0.052	0.15	0.40
0.041	0.15	0.40

NOTE.—For intermediate sizes of wire in the strand the weight designations are the same as for the next finer size shown in the above table.

SAMPLING

Sampling for Tests. 6. In quantities of three or less coils or reels, samples for all tests shall be taken from each reel or coil. In lots of over 3 to 30 coils or reels, at least three samples shall be taken. On larger quantities, samples may be taken from 10 per cent of the lot.

WEIGHT AND UNIFORMITY OF COATING

Weight of Coating.

7. The weight of zinc coating on any individual wire of the completed strand shall be not less than that specified by the purchaser. Weight of coating commercially available on the various sizes of wire, is indicated opposite the nominal diameter in Table I.[1] By contractual arrangement with the manufacturer, heavier coatings than are specified in Table I may be obtained.

Weight of Coating Test.

8. The zinc coating shall be tested for weight by a stripping test in accordance with the requirements of the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[2]

Uniformity of Coating.

9. The uniformity of zinc coating shall be determined by the Preece test as described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[3] This test shall not be used to determine the weight of the coating and shall be applied only after the coating has been found to conform to the requirements of Sections 7 and 8.

The number of dips that "Galvanized" and "Extra-Galvanized" or "Double-Galvanized" wires of the various diameters shall stand without failure shall be as follows:

NOMINAL DIAMETER OF GALVANIZED WIRES IN THE STRAND, IN.	MINIMUM NUMBER OF DIPS	
	"GALVANIZED" COMMON	"EXTRA GALVANIZED" OR "DOUBLE GALVANIZED"
0.041 – 0.061	½	2
0.062 – 0.079	1	2½
0.080 – 0.103	1½	3
0.104 – 0.144	1½	4
0.145 – 0.207	2½	4

Ductility of Steel and Adherence of Coating.

10. The ductility of the steel in the wires of the completed strand and the adherence of the zinc coating on the wires shall be determined by wrapping individual wires at the rate of not more than 15 turns per minute, in a closed helix at least twice around a cylindrical mandrel of a diameter equal to three times the nominal diameter of the individual wire for Common strand, five times for Siemens-Martin, and six times for High Strength and Extra-High Strength. The wires

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[1] Commercial strand of the grade designated as "Common" strand is available in two weights of coating known as "Galvanized" and "Extra Galvanized" or "Double Galvanized." "Extra Galvanized" and "Double Galvanized" are equivalent terms designating heavy coatings applied by a single immersion in zinc. Strand designated as Siemens-Martin, High Strength and Extra-High Strength is furnished only with the coating ordinarily known as "Extra Galvanized" or "Double Galvanized."

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 385.

[3] *Ibid.*, p. 390.

shall stand this test without fracture, and the zinc coating shall adhere firmly to the wire without flaking and without being removable by rubbing with the bare fingers.

PHYSICAL PROPERTIES AND TESTS

Physical Properties. 11. The number of wires in a strand, the size of the component wires, the weight per 1000 ft. of strand, and the minimum breaking strength shall conform to the values given in Table II.

TABLE II.—PHYSICAL PROPERTIES OF GALVANIZED STEEL WIRE STRAND.

Nominal Diameter of the Strand, in.	Number of Wires in Strand	Nominal Diameter of Galvanized Wires in Strand, in.	Approximate Weight of Strand per 1000 ft., lb.	Minimum Breaking Strength of Strand, lb.			
				Common	Siemens-Martin	High Strength	Extra-High Strength
$\frac{1}{8}$	7	0.041	31.8	540	910	1 330	1 830
$\frac{5}{32}$	7	0.052	51.3	870	1 470	2 140	2 940
$\frac{3}{16}$	7	0.062	72.9	1 150	1 900	2 850	3 990
$\frac{7}{32}$	7	0.072	98.3	1 540	2 560	3 850	5 400
$\frac{1}{4}$	7	0.080	121	1 900	3 150	4 750	6 650
$\frac{9}{32}$	7	0.093	164	2 570	4 250	6 400	8 950
$\frac{5}{16}$	7	0.104	205	3 200	5 350	8 000	11 200
$\frac{3}{8}$	7	0.120	273	4 250	6 950	10 800	15 400
$\frac{7}{16}$	7	0.145	399	5 700	9 350	14 500	20 800
$\frac{1}{2}$	7	0.165	517	7 400	12 100	18 800	26 900
$\frac{1}{2}$	19	0.100	504	7 620	12 700	19 100	26 700
$\frac{9}{16}$	7	0.188	671	9 600	15 700	24 500	35 000
$\frac{9}{16}$	19	0.113	637	9 640	16 100	24 100	33 700
$\frac{5}{8}$	7	0.207	813	11 600	19 100	29 600	42 400
$\frac{5}{8}$	19	0.125	796	11 000	18 100	28 100	40 200
$\frac{3}{4}$	19	0.150	1155	16 000	26 200	40 800	58 300
$\frac{7}{8}$	19	0.177	1581	21 900	35 900	55 800	79 700
1	19	0.200	2073	28 700	47 000	73 200	104 500
1	37	0.143	2057	28 300	46 200	71 900	102 700
$1\frac{1}{8}$	37	0.161	2691	36 000	58 900	91 600	130 800
$1\frac{1}{4}$	37	0.179	3248	44 600	73 000	113 600	162 200

Elongation. 12. The elongation of the strand in 24 in. shall be not less than the following:

Common strand	10 per cent
Siemens-Martin	8 per cent
High strength	5 per cent
Extra-high strength	4 per cent

The elongation shall be determined as the increase in separation between the jaws of the testing machine at the initial failure in the sample. The separation of the jaws of the testing machine shall be approximately two feet when under a load equal to 10 per cent of the required minimum breaking strength of the strand. The elongation values shall be recorded only for samples which break over 1 in. from the jaws of the testing machine.

All tensile and elongation tests shall be made on lengths of the strand which do not contain wire joints.

TABLE III.—PERMISSIBLE VARIATIONS IN DIAMETER OF INDIVIDUAL GALVANIZED WIRES IN STRAND.

Nominal Diameter of Strand, in.	Number of Wires in Strand	Diameter of Galvanized Wire, in.		
		Nominal	Maximum	Minimum
1/8	7	0.041	0.043	0.039
5/32	7	0.052	0.054	0.049
3/16	7	0.062	0.065	0.059
7/32	7	0.072	0.075	0.069
1/4	7	0.080	0.083	0.077
9/32	7	0.093	0.097	0.089
5/16	7	0.104	0.108	0.100
3/8	7	0.120	0.125	0.115
7/16	7	0.145	0.151	0.139
1/2	7	0.165	0.171	0.159
1/2	19	0.100	0.104	0.096
9/16	7	0.188	0.194	0.182
9/16	19	0.113	0.118	0.108
5/8	7	0.207	0.213	0.201
5/8	19	0.125	0.130	0.120
3/4	19	0.150	0.156	0.144
7/8	19	0.177	0.183	0.171
1	19	0.200	0.206	0.194
1	37	0.143	0.149	0.137
1 1/8	37	0.161	0.167	0.155
1 1/4	37	0.179	0.185	0.173

SIZE AND PERMISSIBLE VARIATIONS

Size.

13. (*a*) The size of the finished strand shall be expressed as the approximate diameter of the strand in fractions of an inch.

Permissible Variations.

(*b*) The permissible variations from the calculated diameter of the strand shall be:

For strand 5/8 in. and over in diameter.................. ± 0.030 in.
For strand 1/4 and 9/16 in., inclusive, in diameter.......... ± 0.020 in.
For strand 1/8 to 7/32 in., inclusive, in diameter............ ± 0.010 in.

(*c*) The diameter of the galvanized wire forming the strand shall be within the limits shown in Table III.

WORKMANSHIP AND FINISH

Finish. 14. The galvanized wire shall be uniform in diameter and shall be free from splints, scales, inequalities, flaws, and other imperfections not consistent with good commercial practice. The zinc coating shall be smooth and continuous.

PACKING AND MARKING

Packing and Marking. 15. Wire strand shall be furnished in lengths, and in compact coils or on reels as specified by the purchaser, and shall be well protected against mechanical injury in shipping as agreed upon at the time of placing the order.[1] Each coil or reel shall bear a strong tag securely fastened to it showing the length, size and grade of the strand, and the manufacturer's name or mark.

INSPECTION AND REJECTION

Inspection. 16. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture, prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 17. In case there is a reasonable doubt in the first trial as to the failure of the wire or strand to meet any requirement of these specifications, two additional tests shall be made on samples of strand from the same coil or reel, and if failure occurs in either of these tests, the wire or strand shall be rejected.

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[1] Lengths of strand should preferably be in units of 100, 250, 500, 1000, 2500, and 5000-ft. lengths.

TENTATIVE RECOMMENDED PRACTICE

FOR

SAFEGUARDING AGAINST EMBRITTLEMENT OF HOT-GALVANIZED STRUCTURAL STEEL PRODUCTS AND PROCEDURE FOR DETECTING EMBRITTLEMENT[1]

A.S.T.M. Designation: A 143 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

GUIDE FOR AVOIDING EMBRITTLEMENT

Embrittlement.

1. By embrittled galvanized steel is meant material which has lost its ductile properties. Embrittlement may be complete or partial, and seldom manifests itself except at points which have been cold worked, for example, by punching; the effect is noted in specimens with stress concentration, such as is caused by notches, holes, fillets of small radii, sharp bends, etc.

Factors in Embrittlement.

2. (*a*) Any form of cold working reduces the ductility of rolled steel. The reduction in ductility of galvanized material depends upon the type and nature of the steel and the thickness of the sections. Bessemer steel in the smaller sections, from $\frac{1}{8}$ to $\frac{5}{16}$ in. in thickness, may not be susceptible to serious embrittlement. Open-hearth steel in the smaller sections is not affected from a practical point of view. Intermediate size sections of open-hearth steel up to $\frac{11}{16}$ in. in thickness are seldom materially affected; and while the heavier sections $\frac{3}{4}$ in. and over, tend to be susceptible to embrittlement they are not always seriously affected.

(*b*) Pickling roughens the surface and, therefore, has some effect in reducing ductility, but its major effect is a result of hydrogen absorption. The previous treatment of the steel, for example cold working, determines the magnitude of the effect to a large extent. Increasing the temperature of the pickling bath, as well as prolonging the immersion period, increases the resulting embrittlement. Aging in service or heating to 300° F. brings about complete recovery from the effect of hydrogen.

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[1] Prepared by Subcommittee X on Embrittlement Investigation of Committee A-5 on Corrosion of Iron and Steel and based on an investigation made by Battelle Memorial Institute under American Society for Testing Materials' sponsorship. See *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 211 (1931); also paper by Samuel Epstein, "Embrittlement of Hot-Galvanized Structural Steel," see *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

Criticisms of this Tentative Recommended Practice are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

(*c*) In the operation of galvanizing, there is no injurious loss of ductility unless the material has previously received severe localized cold working. When loss of ductility occurs after such cold working, it is due mainly to heating to the galvanizing temperature and to a minor degree to the penetration of zinc or iron-zinc alloy.

(*d*) The tendency of steels toward brittleness is the greater the lower the temperature, and this tendency is increased by cold working and by notch effects. The same steel may be quite ductile at one temperature and much less ductile at a lower temperature. All plain carbon steels become brittle at liquid air temperatures. Some steels lose ductility rapidly as the temperature drops below ordinary room temperature. In others this rapid loss does not occur until temperatures below 0° F. are reached. Hence, the temperature must be controlled in testing. In fabrication and erection it should be remembered that low temperatures involve increased tendency toward brittleness.

Steels. 3. Only steels produced under the trade designation of open-hearth should be used for galvanizing if any cold working without subsequent annealing or stress relieving is to precede galvanizing.

Cold Working. 4. (*a*) The physical properties of structural steel are changed by cold working. Certain properties are raised; others are lowered; thus, hardness is increased and shock resisting properties are decreased. Cold working may be of the nature of rolling, bending, upsetting, punching, or shearing, etc.

(*b*) For intermediate and heavy shapes and plates, sharp bending should preferably be done hot, but if done cold the material should subsequently be annealed or stress relieved. Cold processed rods and bolts may require annealing or stress relieving.

(*c*) The smaller shapes, including thickness up to $\frac{1}{4}$ in., may be cold worked by punching without subsequent annealing or stress relieving. Shapes $\frac{5}{16}$ to $\frac{11}{16}$ in. in thickness are not seriously affected as to serviceability by cold working in punching if the punching is done under good shop practice. The heavier shapes, $\frac{3}{4}$ in. and over, should be reamed after punching, or be drilled.

Necessity for Tests. 5. (*a*) The use of open-hearth steel made in accordance with the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials,[1] or equivalent, and fabricated in accordance with the recommendations of Section 4 (*b*) and (*c*) should avoid injurious embrittlement. Such material and workmanship are accepted without testing for embrittlement.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

(*b*) If the purchaser desires embrittlement tests of galvanized angles which are of a steel or workmanship differing from those described in Paragraph (*a*), or for other reasons, such tests should be made in accordance with Sections 6, 7 and 8.

(*c*) The purchaser shall bear the expense of making all embrittlement tests and the responsibility for delays in shipment incidental thereto.

GALVANIZED ANGLE TEST

Test Requirements.

6. (*a*) The elongation measured in accordance with Section 7 (*a*) shall not be less than 5 per cent except as specified in Paragraph (*b*).

(*b*) When the specimen does not show 5 per cent elongation, the reduction in thickness shall be measured in accordance with Section 7 (*b*). The sum of the percentage of elongation plus the average percentage reduction of thickness shall not be less than 10.

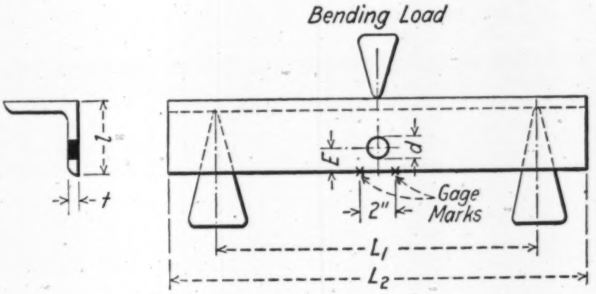

FIG. 1.

Method of Test.

7. (*a*) For determining the elongation after fracture, a 2-in. gage length (Fig. 1) shall be prick-punched in the middle of the edge of the vertical leg of the angle along a line parallel to its length and centered directly under the hole. After the test, the sum of the distances along this line from each punch mark to the corresponding edge of the fracture shall be measured to 0.01 in. with a flexible scale and the percentage of elongation calculated. For specimens under $\frac{1}{2}$ in. in thickness, or those in which the distance from the edge of the hole to the edge of the angle is less than $\frac{3}{8}$ in., the elongation shall be measured over a 1-in. gage length.

(*b*) For determining the percentage reduction of thickness after fracture, the reduction shall be measured with a ball-point micrometer at the three locations indicated in Fig. 2: namely, *a*, outer side of hole; *b*, inner side of hole; *c*, middle of leg. The percentage reduction of thickness shall be calculated on the basis of the original thickness of the angle and the average of the three values at *a*, *b*, and *c*.

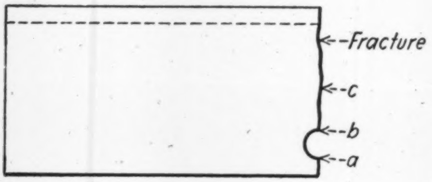

FIG. 2.

(*c*) The length of the test specimen and the distance between the supports are shown in the following table:

LEG OF ANGLE, l, IN.	LENGTH BETWEEN SUPPORTS, L_1, IN.	MINIMUM LENGTH, L_2, IN.
Up to 4 incl.	14	18
Over 4 to 6 incl.	20	24
Over 6 to 8 incl.	30	36

(*d*) The kind of hole, punched, sub-punched and reamed, or drilled, shall be that employed in the fabricated material which the specimen represents. The dimensional values, diameter and location of hole, shall not be less than those employed in the structural details. Care should be taken not to place the hole near stamped or rolled-in identification marks.

(*e*) The test shall be made upon galvanized specimens having a temperature not below 60° F. and not over 90° F. when tested.

(*f*) The test may be made in a universal testing machine, or by other means such as a press or bulldozer with the load applied slowly.

Number of Tests. 8. One test from each thickness of angle from each melt of steel shall be made. In case there is a reasonable doubt that the angles represented by the specimens in the first test are not free of injurious embrittlement, two additional tests shall be made, and if no failure to meet the requirements of Section 6 (*a*) and (*b*) occurs in either of these tests the angles represented shall be considered acceptable.

TENTATIVE SPECIFICATIONS
FOR
CAST-IRON CULVERT PIPE[1]

A.S.T.M. Designation: A 142 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover cast-iron pipe intended for use in the construction of culverts.

Classes. 2. These specifications cover three classes of pipe: namely, Standard Cast-Iron Culvert Pipe; Heavy Cast-Iron Culvert Pipe, and Extra-Heavy Cast-Iron Culvert Pipe.

Type of Pipe. 3. (*a*) Each length of pipe shall be cast as a unit and shall have a full circular cross-section with outside and inside circumferences concentric. Unless otherwise specified, the pipe may be smooth, corrugated or ribbed.

(*b*) The pipe shall be provided with suitable devices, such as hub ends or interlocking ends, to prevent displacement at joints.

MANUFACTURE

Material. 4. The pipe shall be manufactured of cast iron of good quality and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to admit satisfactorily of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola, air-furnace, or electric furnace.

Casting. 5. Pipe may be cast either vertically or horizontally in dry or green-sand molds or by centrifugal processes.

Coating. 6. (*a*) All pipe shall be completely coated inside and out by immersion in coal-tar pitch varnish to which sufficient oil shall have been added to make a smooth coating, tough and tenacious when cold, and not tacky nor brittle nor with any tendency to scale off.

(*b*) Prior to dipping, the pipe shall be thoroughly cleaned of rust, loose scale, grease and dirt.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

7. (*a*) The iron shall conform to the following ladle analysis requirements as to chemical composition:

Phosphorus, maximum, per cent	0.90
Sulfur, maximum, per cent	0.12

(*b*) The manufacturer shall maintain a daily record of chemical analyses, and the portions of this record which concern pipe ordered by a purchaser shall be open to the inspection of the purchaser at all times.

PHYSICAL PROPERTIES AND TESTS

Strength Requirements.

8. The pipe shall not fail and shall develop no visible cracks when tested under the following loads by the three-edge-bearing method:

CLASS OF PIPE	LOAD, LB. PER FOOT, OF LAYING LENGTH
Standard pipe	2000D
Heavy pipe	3000D
Extra-heavy pipe	4000D

NOTE.—D = Nominal inside diameter of pipe in feet.

(*b*) Pipe specimens tested for strength shall not be tested to destruction if they will sustain, without cracking, a load 10 per cent in excess of the specified load. If the purchaser desires tests to destruction he shall specify on the order the number of such tests which will be required.

Three-Edge-Bearing Method.

9. The lower bearing for the pipe shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be straight and shall be securely fastened to a rigid block with the interior vertical faces spaced at a distance apart not less than ½ in. nor more than 1 in. for each foot of nominal pipe diameter, with a minimum spacing of 1 in. for any size of pipe. The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the barrel of the pipe exclusive of the bell, if any. The pipe shall be placed symmetrically between the two bearings and the center of the application of load shall be at the center of the length of pipe, as illustrated in Figs. 1 and 2. In testing pipe which is "out of line" the lines of the bearings chosen shall be from those which appear to give the most favorable conditions for fair test. In testing pipe, the

specimen shall be placed so that the upper bearing will be along the thinnest element.

Testing Apparatus.

10. Any mechanically driven or hand-power device, which meets the following requirements, may be used:

(*a*) It shall be substantially built and rigid throughout so that the distribution of the load to the specimen will not be affected appreciably by the deformation or yielding of any part.

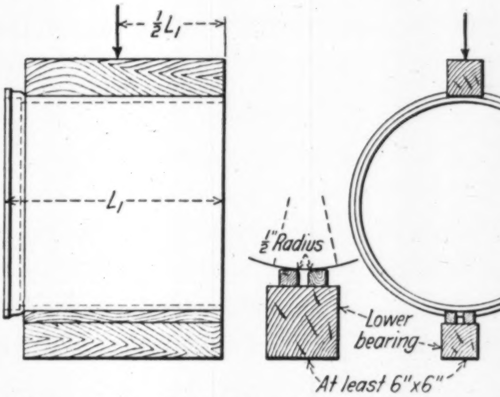

FIG. 1.—Three-Edge Bearings for Pipe with Bell End.

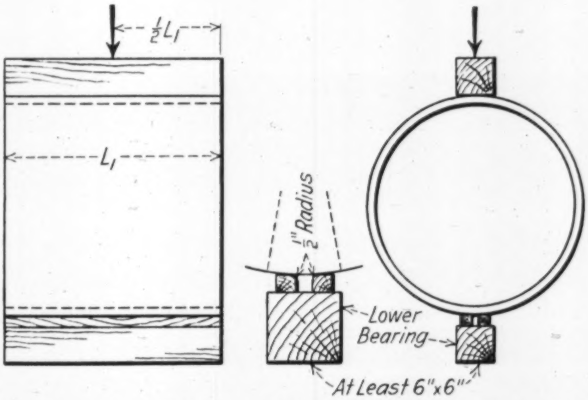

FIG. 2.—Three-Edge Bearings for Pipe Without Bell End.

(*b*) It shall provide for an approximately continuous application of load by means of a head which, during the test, moves at an approximately uniform rate not to exceed:

0.05 in. per minute for pipe less than 24 in. in diameter
0.10 in. per minute for pipe 24 to 36 in. in diameter
0.20 in. per minute for pipe more than 36 in. in diameter

(*c*) It shall provide means for the determination of load with an error not greater than 2 per cent.

Number of Tests. 11. The purchaser may require strength tests in such numbers as he may deem necessary, provided that if the pipe meets the requirements as to shell thickness and weight, the number of specimens tested shall not exceed three pipe or 5 per cent, whichever may be larger, of each size and class ordered. In placing an order the purchaser shall specify the number of strength tests which will be required.

Selection of Test Specimens. 12. All pipe for purpose of tests shall be selected at random by the purchaser from the stock of the manufacturer, or from the pipe as delivered to the work, and shall be pipe which would not otherwise be rejected under these specifications.

Length of Test Specimens. 13. The laying length of test specimens of pipe shall be not less than 3 nor more than 4 ft. If the manufacturer proposes to furnish, for use in the work, pipe having a length greater than 4 ft., he shall furnish for the required tests a sufficient number of test specimens of the required length.

Testing and Disposal of Test Specimens. 14. Pipe specimens shall be tested under a load 10 per cent in excess of the load specified for the particular class of pipe. Shipments represented by specimens which sustain the specified load without the development of visible cracks shall be accepted. Specimens of pipe which sustain a load 10 per cent in excess of that specified without the development of visible cracks shall be accepted. The cost of specimens which fail to sustain the specified load, or a load 10 per cent in excess of that specified, shall be borne by the manufacturer.

NOTE.—It is recommended that a test specimen which has been accepted for use be marked with a suitable identification symbol and be installed in the culvert structure in such location as will subject it to the least severe loading.

Retests. 15. Pipe shall be acceptable under the strength tests when all test specimens fulfill the strength test requirements. Should any pipe fail to meet the test requirements, then the manufacturer will be allowed a retest on two similar specimens for each specimen that failed, and the pipe shall be acceptable only when all of these retest specimens fulfill the test requirements. No further retests shall be permitted.

SIZES, WEIGHTS AND PERMISSIBLE VARIATIONS

Diameter. 16. (*a*) The minimum nominal diameter of pipe shall be 12 in.

(*b*) The minimum inside diameter of any pipe shall be not less than the nominal diameter by more than $\frac{1}{8}$ in.

Length. 17. Pipe shall have a minimum laying length of 3 ft. Unless otherwise specified, the maximum laying length shall be 12 ft.

Dimensions and Weight.

18. (*a*) The shell thickness and the weights per linear foot for pipe of the various classes shall conform to the requirements given in Tables I and II.

(*b*) The shell thickness at any point shall be not more than 15 per cent under the thickness specified in Tables I and II.

(*c*) The weight of any section of pipe shall be not more than 5 per cent under the weight specified in Tables I and II.

TABLE I.—DIMENSIONS AND WEIGHTS OF SMOOTH CAST-IRON CULVERT PIPE.

Nominal Diameter, in.	Standar Pipe (2000*D*)		Heavy Pipe (3000*D*)		Extra-Heavy Pipe (4000*D*)	
	Nominal Thickness, in.	Nominal Weight per Foot of Barrel, lb.[1]	Nominal Thickness, in.	Nominal Weight per Foot of Barrel, lb.[1]	Nominal Thickness, in.	Nominal Weight per Foot of Barrel, lb.[1]
12	0.37	45	0.37	45	0.40	49
14	0.37	52	0.40	57	0.46	65
16	0.40	64	0.46	74	0.53	86
18	0.42	76	0.52	95	0.60	110
20	0.47	94	0.57	115	0.66	134
24	0.56	135	0.69	167	0.80	195
30	0.70	211	0.86	261	1.00	304
36	0.84	304	1.03	374	1.20	438
42	0.98	414	1.20	509	1.40	597
48	1.12	540	1.38	669	1.60	779

[1] All weight values are per foot of barrel exclusive of hub.

TABLE II.—DIMENSIONS AND WEIGHTS OF CORRUGATED CAST-IRON CULVERT PIPE AND RIBBED CAST-IRON CULVERT PIPE.

	STANDARD PIPE (2000*D*)	
NOMINAL DIAMETER, IN.	NOMINAL THICKNESS, IN.	NOMINAL WEIGHT PER FOOT OF BARREL, LB.
15	0.25	45
18	0.25	50
24	0.31	85
30	0.38	125
36	0.44	165

Waiver of Strength Tests.

19. After the strength, shell thickness and weight of pipe of a particular class and size furnished by the manufacturer has been established by tests, the purchaser may elect to waive further strength tests and to accept pipe of that particular class, size and manufacture on the basis of the shell thickness and weight thus established, subject to the tolerances specified in Section 18 (*b*) and (*c*). Under these conditions the acceptability of the larger sizes of pipe shall not be based on the results of strength tests on smaller sizes.

WORKMANSHIP AND FINISH

Character of Castings. 20. (*a*) Pipe shall be practically straight and of true circular cross-section. They shall be sound, smooth and free from cracks, scales, lumps, blisters, sand holes, "cold shuts," or other defects which would render them unfit for the use intended.

(*b*) All pipe shall be carefully examined for defects and sounded with a hammer before shipment. No fillings with metal, cement or other material, or so-called "burning on" of iron will be permitted.

WEIGHING AND MARKING

Weighing. 21. If required by the purchaser, each pipe shall be weighed and, after coating, the weight plainly marked thereon with white paint.

Marking. 22. The brand of the manufacturer shall be legibly stamped-in or cast or stencilled on the metal of each pipe.

INSPECTION AND REJECTION

Inspection. 23. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities including labor to satisfy him that the pipe are being furnished in accordance with these specifications. All tests and inspections shall, if possible, be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser reserves the right, if deemed necessary, to inspect and test the pipe after delivery on the work.

Rejection. 24. (*a*) All pipes which fail to conform to any of the provisions of these specifications shall be subject to rejection.

(*b*) Pipes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified promptly.

TENTATIVE SPECIFICATIONS
FOR
GRAY-IRON CASTINGS[1]

A.S.T.M. Designation: A 48 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

1. These specifications cover general gray-iron castings not covered by other existing specifications of the American Society for Testing Materials. These specifications apply to gray-iron castings where strength is a consideration. It is the purpose of these specifications to classify cast irons in respect to tensile strength. **Scope.**

PHYSICAL PROPERTIES AND TESTS

2. Gray-iron castings conforming to these specifications shall be known and listed by classes. These classes are listed according to minimum tensile strengths of test bars as follows: **Classification, Tensile Strength.**

CLASS	TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.
No. 20	20 000
No. 25	25 000
No. 30	30 000
No. 35	35 000
No. 40	40 000
No. 50	50 000
No. 60	60 000

3. (*a*) Transverse tests are optional and the following minimum breaking loads are specified: **Transverse Tests.**

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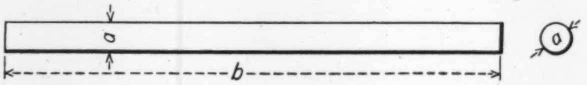
[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

These specifications are in effect a tentative revision of, and will supersede, when adopted as standard, the present Standard Specifications for Gray-Iron Castings (A.S.T.M. Designation: A 48 - 29), 1930 Book of A.S.T.M. Standards, Part I, p. 494, and Standard Specifications for High-Test Gray-Iron Castings (A.S.T.M. Designation: A 88 - 31), 1931 Supplement to Book of A.S.T.M. Standards, p. 19.

Transverse Test Bar...........	0.875 in. in Diameter	1.2 in. in Diameter	2.0 in. in Diameter
Span Length....	12-in. Supports	18-in. Supports	24-in. Supports
CLASS	LOAD AT CENTER, LB.	LOAD AT CENTER, LB.	LOAD AT CENTER, LB.
No. 20.........	900	1700	4 500
No. 25.........	1050	1900	5 500
No. 30.........	1200	2100	6 500
No. 35.........	1300	2300	7 500
No. 40.........	1400	2500	9 000
No. 50.........	1700	2800	11 000
No. 60.........	2000	3100	13 000

(*b*) By agreement between the manufacturer and purchaser, deflection values in the transverse test may be specified.

(*c*) The transverse test shall be made on the bar as cast with central loading between supports. Corrections shall be made for sizes of bars as shown in Table I. The controlling dimension shall be the diameter of the bar at the fracture. The rate of application of the load shall be such that fracture is produced in not less than 15 seconds for the 0.875-in. diameter bar; 20 seconds for the 1.2-in. diameter bar, and 40 seconds for the 2.0-in. diameter bar.



TRANSVERSE TEST BAR	DIMENSIONS DIAMETER (*a*)	DIMENSIONS LENGTH (*b*)	DISTANCE BETWEEN SUPPORTS IN TRANSVERSE TEST
A..........................	0.875 in.	15 in.	12 in.
B..........................	1.20 in.	21 in.	18 in.
C..........................	2.00 in.	27 in.	24 in.

FIG. 1.—Transverse Test Bars.

Test Bars.

4. (*a*) Tension and transverse test bars shall be cast separately from the casting. Three tension, three optional tension, and three transverse test bars shall be available, the size of test bar used depending upon the controlling section of the casting. The form and dimensions of the test bars are shown in Figs. 1, 2 and 3.

(*b*) Instead of using the separately cast tension test bar shown in Fig. 2, it is optional to use test specimens machined from the transverse test bars. In such cases, the form and dimensions of the optional tension test specimen shall be as shown in Fig. 3.

Correlation of Test Bar and Casting.

5. (*a*) The manufacturer and purchaser shall agree upon the controlling section of the casting. Then the corresponding test bar shall be used as follows:

CONTROLLING SECTION OF CASTING	TEST BAR	NOMINAL DIAMETER OF TEST BAR AS CAST
0.75 in., maximum	*A*	0.875 in.
0.76 to 1.10 in.	*B*	1.20 in.
1.11 to 2.00 in.	*C*	2.00 in.

(*b*) For sections of castings over 2.00 in., test bar *C* may be used or a larger test bar may be used by mutual agreement between the manufacturer and purchaser.

(*c*) The above correlation is only approximate and may need modification for complicated castings. The test bar size for a given casting may then be determined by mutual agreement between the manufacturer and purchaser.

TABLE I.—CORRECTION FACTORS FOR TRANSVERSE TEST BARS.

In order to correct to the standard diameter the breaking load obtained in testing the bar shall be divided by the correction factor.

0.875 in. Diameter Bar		1.20 in. Diameter Bar		2.00 in. Diameter Bar	
Diameter of Test Bars, in.	Correction Factor	Diameter of Test Bars, in.	Correction Factor	Diameter of Test Bars, in.	Correction Factor
0.825	0.838	1.10	0.770	1.90	0.857
0.830	0.853	1.11	0.791	1.91	0.871
0.835	0.869	1.12	0.813	1.92	0.885
0.840	0.885	1.13	0.835	1.93	0.899
0.845	0.900	1.14	0.857	1.94	0.913
0.850	0.916	1.15	0.880	1.95	0.927
0.855	0.933	1.16	0.903	1.96	0.941
0.860	0.949	1.17	0.927	1.97	0.955
0.865	0.966	1.18	0.951	1.98	0.970
0.870	0.983	1.19	0.975	1.99	0.985
0.875	1.000	1.20	1.000	2.00	1.000
0.880	1.017	1.21	1.025	2.01	1.015
0.885	1.034	1.22	1.051	2.02	1.030
0.890	1.051	1.23	1.077	2.03	1.046
0.895	1.069	1.24	1.103	2.04	1.061
0.900	1.087	1.25	1.130	2.05	1.076
0.905	1.106	1.26	1.158	2.06	1.092
0.910	1.125	1.27	1 185	2.07	1.109
0.915	1.143	1.28	1.214	2.08	1.125
0.920	1.162	1.29	1.242	2.09	1.141
0.925	1.181	1.30	1.271	2.10	1.158

6. Tension test specimens shall fit the holders of the testing machine in such a way that the load shall be axial. The use of self-aligning shackles is recommended. **Tensile Strength Test.**

NOTE.—Suitable ball and socket specimen holders and spherical-seated bearing devices are shown in Figs. 1, 2 and 3 and described in Section 8 of the Tentative Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8 - 32 T) of the American Society for Testing Materials.[1]

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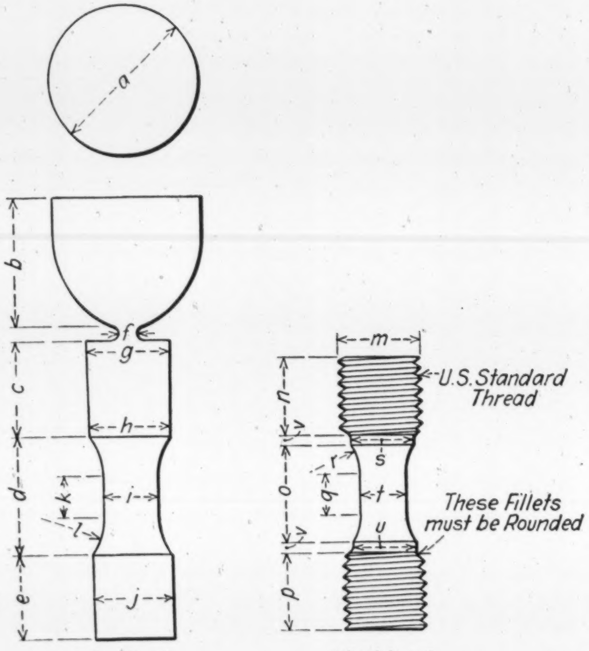
[1] See p. 947.



As Cast

Machined

FIG. 2.—Tension Test Bars.

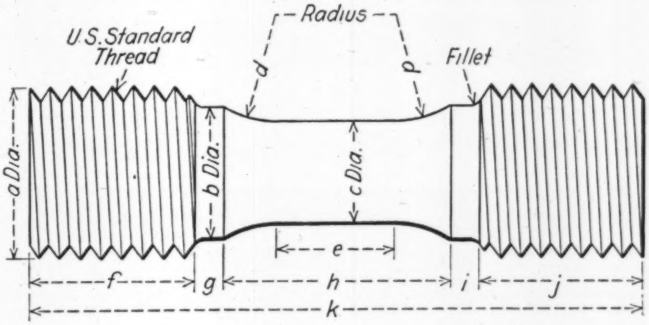
DIMENSION	DIMENSIONS OF TEST BARS TEST BAR *A*	TEST BAR *B*	TEST BAR *C*
		BARS, AS CAST	
a	3 in.	$3\frac{1}{2}$ in.	$4\frac{1}{2}$ in.
b	$2\frac{1}{2}$ in.	3 in.	$4\frac{1}{2}$ in.
c	2 in.	$2\frac{1}{4}$ in.	$3\frac{3}{4}$ in.
d	$1\frac{3}{4}$ in.	$2\frac{3}{4}$ in.	5 in.
e	$1\frac{3}{4}$ in.	2 in.	$3\frac{1}{8}$ in.
f	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.
g	$1\frac{7}{16}$ in.	2 in.	$3\frac{1}{8}$ in.
h	$1\frac{3}{8}$ in.	$1\frac{7}{8}$ in.	$2\frac{7}{8}$ in.
i	$\frac{7}{8}$ in.	1.20 in.	2 in.
j	$1\frac{3}{8}$ in.	$1\frac{7}{8}$ in.	$2\frac{7}{8}$ in.
k	$\frac{7}{8}$ in.	1 in.	2 in.
l	$\frac{3}{4}$ in.	$1\frac{1}{4}$ in.	3 in.
		MACHINED SPECIMENS	
m	$1\frac{1}{8}$ in.	$1\frac{3}{4}$ in.	$2\frac{3}{4}$ in.
n	1 in.	$1\frac{3}{4}$ in.	$2\frac{3}{4}$ in.
o	$1\frac{1}{2}$ in.	$2\frac{1}{4}$ in.	$4\frac{1}{4}$ in.
p	1 in.	$1\frac{3}{4}$ in.	$2\frac{3}{4}$ in.
q	$\frac{3}{4}$ in.	1 in.	$1\frac{3}{4}$ in.
r	1 in.	2 in.	4 in.
s	$\frac{15}{16}$ in.	$1\frac{5}{16}$ in.	$2\frac{1}{8}$ in.
t	0.800 in.	1.10 in.	1.80 in.
u	$\frac{15}{16}$ in.	$1\frac{5}{16}$ in.	$2\frac{1}{8}$ in.
v	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.

Correlation, Tension and Transverse Test Bars.

7. There is no definite factor for correlation between tensile and transverse strengths for various types of gray cast iron. The table included in Section 3 shows minimum values only. In cases where the manufacturer and purchaser agree upon transverse tests to govern, the proper range of transverse values may be taken from the table in Section 3 or may be determined by pouring transverse and tension bars and then establishing a correlation for that particular cast iron.

Molding and Pouring Test Bars.

8. Unless otherwise agreed upon by the manufacturer and purchaser, tension and transverse test bars shall be made under the same sand conditions as the casting. The bars shall be poured from a ladle or ladles of iron used to pour the castings. Pouring shall be done as nearly as possible at the same temperature at which the casting is poured. The test bars shall receive the same mechanical and thermal treatment as the castings. In the case of heat treatment, the test bars are to be treated adjacent to the castings they represent.



DIMENSION	DIMENSIONS OF TEST BARS TEST BAR *A*	 TEST BAR *B*	 TEST BAR *C*
a	$\frac{3}{4}$ in.	$1\frac{1}{8}$ in.	$1\frac{7}{8}$ in.
b	$\frac{5}{8}$ in.	$\frac{15}{16}$ in.	$1\frac{7}{16}$ in.
c	0.505 in.	0.800 in.	1.25 in.
d	1.00 in.	1.00 in.	2.00 in.
e[a]	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$1\frac{1}{4}$ in.
f	1.00 in.	1.00 in.	$1\frac{3}{4}$ in.
g	0.25 in.	0.25 in.	$\frac{5}{16}$ in.
h	1.25 in.	1.50 in.	$2\frac{1}{4}$ in.
i	0.25 in.	0.25 in.	$\frac{5}{16}$ in.
j	1.00 in.	1.00 in.	$1\frac{3}{4}$ in.
k	3.75 in.	4.00 in.	$6\frac{3}{8}$ in.

[a] Length of parallel.

FIG. 3.—Optional Tension Test Specimen Machined from Transverse Test Bars.

Tests and Retests.

9. (*a*) The manufacturer shall supply and prepare all test bars as agreed upon. Two or more test bars shall be cast.

(*b*) If a faulty or unsound test bar gives a result not in accord with the specifications, the result shall be disregarded and another test made.

(*c*) In case of failure of a test bar a retest may be made. If the retest fails, the castings shall be rejected.

(*d*) In case no sound test bars are available for retest and optional transverse bars are available, tensile strength tests may be made on test specimens machined from transverse test bars, the dimensions to be as shown in Fig. 3.

CHEMICAL COMPOSITION

Chemical Analysis.

10. It is the intent of these specifications to subordinate chemical composition to physical properties. By agreement between the manufacturer and purchaser, the quantities of any chemical elements in the cast iron may be specified.

WORKMANSHIP AND FINISH

Workmanship and Finish.

11. The castings shall be true to pattern and free from cracks, gas holes, flaws and excessive shrinkage. Surfaces of the castings shall be free from burnt-on sand and shall be reasonably smooth. Runners, risers, fins and other cast-on pieces shall be removed. In other respects the castings shall conform to whatever points may be specially agreed upon between the manufacturer and purchaser.

INSPECTION

Inspection.

12. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted, as not to interfere unnecessarily with the operation of the works.

CERTIFICATION

Certification.

13. Upon request of the buyer, the manufacturer shall be prepared to certify that his product conforms to the requirements of these specifications.

EXPLANATORY NOTES

NOTE 1.—Classes Nos. 20, 25 and 30 cover the ordinary grades of gray cast iron. Classes Nos. 35, 40, 50 and 60 would be considered high-strength irons, particularly in medium and heavy sections.

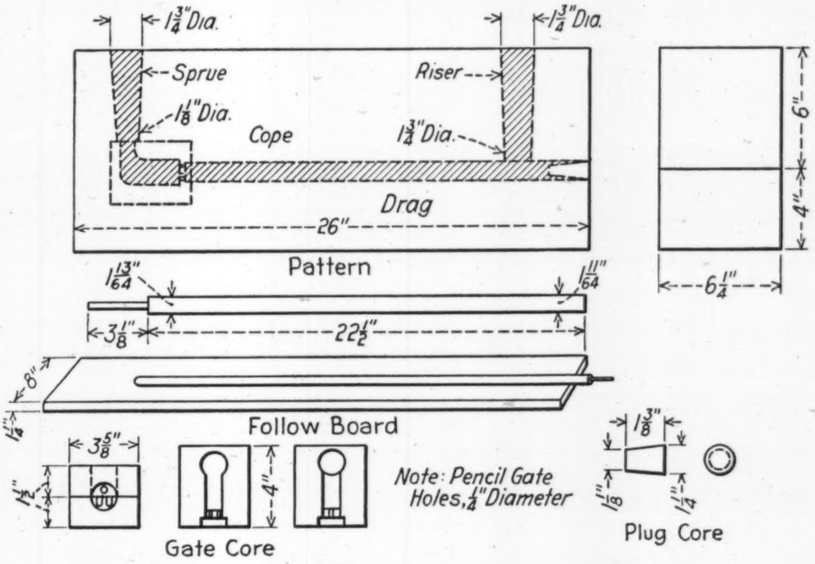

1¾" Dia.
1¾" Dia.
Sprue
Riser
1⅛" Dia.
Cope
1¾" Dia.
Drag
26"
6"
4"
6¼"
Pattern
1 13/64"
1 11/64"
3⅛"
22½"
8"
1¼"
Follow Board
3⅝"
1½"
4"
Gate Core
Note: Pencil Gate Holes, ¼" Diameter
1⅜"
1⅛"
1¼"
Plug Core

FIG. 4.—Transverse Test Bar, 1.20-in. Diameter, Cast Horizontally.

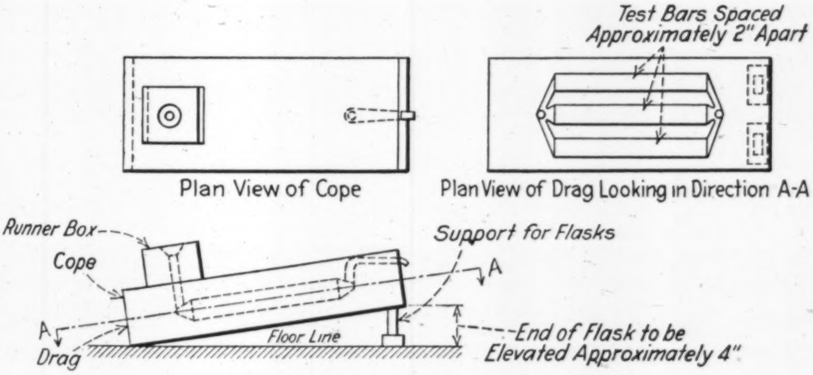

Test Bars Spaced Approximately 2" Apart
Plan View of Cope
Plan View of Drag Looking in Direction A-A
Runner Box
Cope
Support for Flasks
A
A
Drag
Floor Line
End of Flask to be Elevated Approximately 4"

FIG. 5.—Test Bar Cast on Incline.

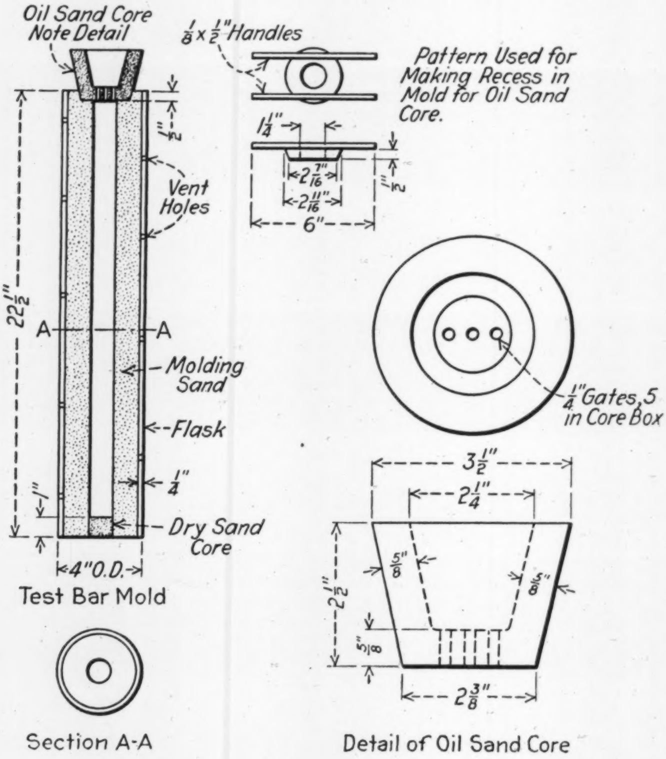
Arrangement of Flasks for Casting Test Bars.

NOTE 2.—The higher-strength irons are usually more expensive to produce because of the following:

(a) Special melting methods;
(b) Possible use of expensive alloys; and
(c) Changed practice in molding and pouring.
(d) Improved technique and supervision.

NOTE 3.—In general, the higher-strength irons are more difficult to machine, also more difficult to produce in heavy sections. Consequently, specifying a stronger cast iron than is needed may result in unnecessarily increased costs in producing the casting and in machining.

NOTE 4.—One method of making tension test bars is shown in Fig. 2. Cores are made in oil sand and baked in halves. The halves are pasted together when cold. The tension test bar can be made in green sand if desired.


Oil Sand Core Note Detail
1/8 x 1/2" Handles
Pattern Used for Making Recess in Mold for Oil Sand Core.
1/2"
1 1/4"
2 7/16"
2 11/16"
6"
1/2"
Vent Holes
22 1/2"
A
A
Molding Sand
Flask
1/4"
1"
Dry Sand Core
4" O.D.
1/4" Gates, 5 in Core Box
3 1/2"
2 1/4"
5/8"
5/8"
2 1/2"
5/8"
2 3/8"

Test Bar Mold

Section A-A

Detail of Oil Sand Core

FIG. 6.—Transverse Test Bar Cast Vertically.

NOTE 5.—A sound test bar is desired. Several methods of making transverse test bars are shown in Figs. 4, 5 and 6. All of these methods have been used and found to produce satisfactory results. Another method of making a transverse test bar is shown in Fig. 1 of the Standard Specifications for the Arbitration Test Bar and Tension Test Specimen for Cast Iron (A.S.T.M. Designation: A 124) of the American Society for Testing Materials.[1]

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 503.

TENTATIVE SPECIFICATIONS
FOR
MALLEABLE IRON CASTINGS[1]

A.S.T.M. Designation: A 47 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope.

1. These specifications cover malleable iron castings for railroad, motor vehicle, agricultural implement, and general machinery purposes.

MANUFACTURE

Process.

2. The castings shall be produced by either the air-furnace, open-hearth, or electric-furnace process.

Primary Graphite.

3. Castings shall be free from primary graphite.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

4. (*a*) The tension test specimen specified in Section 6 shall conform to the following minimum requirements as to tensile properties:

	GRADE No. 32510	GRADE No. 35018
Tensile strength, lb. per sq. in.	50 000	53 000
Yield point, lb. per sq. in.	32 500	35 000
Elongation in 2 in., per cent	10.0	18.0

(*b*) The yield point, defined as that load under which the specimen has an elongation in 2 in. of 0.01 in., may be determined by the drop of the beam of the testing machine or by the divider method.

Special Tests.

5. (*a*) All castings, if of sufficient size, shall have cast thereon test lugs of a size proportional to the thickness of the casting, but not exceeding $\frac{5}{8}$ by $\frac{3}{4}$ in. in cross-section. On castings which are 24 in. or over in length, a test lug shall be cast near each end. These test lugs shall be attached to the casting at such a point that they will not interfere with the assembling of the castings, and may be broken off by the inspector.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Enrique Touceda, Secretary of Committee A-7 on Malleable Iron Castings, 943 Broadway, Albany, N. Y.

These specifications are in effect a tentative revision of and will supersede when adopted as standard, the present Standard Specifications for Malleable Castings (A 47 - 30), see 1930 Book of A.S.T.M. Standards, Part I, p. 491.

(*b*) If the purchaser or his representative so desires, a casting may be tested to destruction. Such a casting shall show good, tough malleable iron.

Tension Test Specimens.

6. (*a*) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Specimens whose mean diameter at the smallest section is less than $\frac{19}{32}$ in. will not be accepted for test.

(*b*) A set of three tension test specimens shall be cast from each melt, without chills, using heavy risers of sufficient height to secure sound bars. The specimens shall be suitably marked for identification with the melt. Each set of specimens so cast shall be placed in some one oven containing castings to be annealed.

Number of Tests.

7. (*a*) After annealing, three tension test specimens shall be selected by the inspector as representing the castings in the oven from which these specimens are taken.

(*b*) If the first specimen conforms to the specified requirements, or if in the event of failure of the first specimen the second and third specimens conform to the requirements, the castings in that oven shall be accepted, except that any casting may be rejected if its test lug shows that it has not been properly annealed. If either the second or third specimen fails to conform to the requirements, the entire contents of that oven shall be rejected.

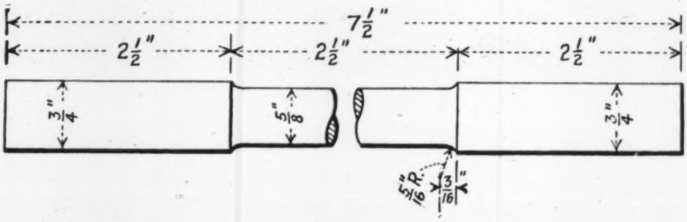

FIG. 1.—Tension Test Specimen.

(*c*) *Retests.*—In case one of the retest specimens contains a flaw which results in the failure of the specimen to meet the specifications, at the discretion of the inspector additional test specimens from the same oven may be tested, or test specimens cut from castings may be tested.

Re-annealing.

8. Any castings rejected for insufficient annealing may be re-annealed once. The re-annealed castings shall be inspected and if the remaining test lugs, or castings broken as specimens, show the castings to be thoroughly annealed, they shall be accepted; if not, they shall be finally rejected.

WORKMANSHIP AND FINISH

Workmanship. 9. The castings shall conform substantially to the patterns or drawings furnished by the purchaser, and also to gages which may be specified in individual cases. The castings shall be made in a workmanlike manner. A variation of $\frac{1}{8}$ in. per ft. will be permitted.

Finish. 10. The castings shall be free from injurious defects.

MARKING

Marking. 11. The manufacturer's identification mark and the pattern numbers assigned by the purchaser shall be cast on all castings of sufficient size, in such positions that they will not interfere with the service of the castings.

INSPECTION AND REJECTION

Inspection. 12. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The manufacturer shall be required to keep a record of each melt from which castings are produced, showing tensile strength and elongation of test specimens cast from such melts. These records shall be available and shown to the inspector whenever required.

Rejection. 13. Castings which show injurious defects subsequent to their acceptance at the manufacturer's works may be rejected, and, if rejected, shall be replaced by the manufacturer without charge to the purchaser.

TENTATIVE SPECIFICATIONS
FOR
FERRO-TUNGSTEN[1]

A.S.T.M. Designation: A 144 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover the standard grade of ferro-tungsten only.

Basis of Purchase. 2. Unless otherwise specified, ferro-tungsten shall be furnished crushed to a size 1 in. and less.

Chemical Composition. 3. (*a*) The material shall conform to the following requirements as to chemical composition:

Tungsten	75.00 to 85.00 per cent, as specified
Carbon, maximum	0.75 per cent
Phosphorus, maximum	0.06 per cent
Sulfur, maximum	0.06 per cent
Silicon, maximum	1.00 per cent
Manganese, maximum	1.00 per cent
Copper, maximum	0.15 per cent
Arsenic, maximum	0.10 per cent
Antimony, maximum	0.08 per cent
Tin, maximum	0.10 per cent
Sum of arsenic, antimony and tin, maximum	0.20 per cent

(*b*) The manufacturer shall furnish an analysis of each shipment showing the tungsten content and when required such of the other elements specified in Paragraph (*a*).

Sampling. 4. The sampling shall be carried out in accordance with the procedure for High-Carbon Ferro-Chromium, Chromium Metal, Low-Carbon Ferro-Manganese and Manganese Metal described in the Standard Methods of Sampling Ferro-Alloys (A.S.T.M. Designation: A 103) of the American Society for Testing Materials.[2]

Methods of Chemical Analysis. 5. The chemical analysis shall be carried out in accordance with the procedure for ferro-tungsten in the Tentative Methods of Chemical

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall St., New York City.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 543.

Analysis of Ferro-Tungsten and Ferro-Molybdenum (A.S.T.M. Designation: A 104 – 32 T) of the American Society for Testing Materials.[1]

6. Ferro-tungsten shall be packed in sound containers in such manner that none of the metal is lost in shipment. **Packing.**

7. (*a*) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the sampling, packing and shipping of material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. **Inspection.**

(*b*) If the purchaser so elects, the material may be sampled by him at the destination, in which case at least 10 per cent of the containers shall be sampled.

8. Any claims or rejections based on check analysis shall be made within 30 days from receipt of material. **Rejection.**

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[1] See p. 641.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON FERRO-MOLYBDENUM[1]

A.S.T.M. Designation: A 145 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover low-carbon ferro-molybdenum only.

Basis of Purchase. 2. Unless otherwise specified, low-carbon ferro-molybdenum shall be furnished crushed to a size 1 in. and less.

Chemical Composition. 3. (*a*) The material shall conform to the following requirements as to chemical composition:

Carbon, maximum	0.25 per cent
Molybdenum	55.00 to 65.00 per cent
Silicon, maximum	1.50 per cent
Sulfur, maximum	0.25 per cent
Phosphorus, maximum	0.10 per cent
Copper, maximum	0.25 per cent

(*b*) The manufacturer shall furnish an analysis of each shipment showing the molybdenum content and when required such of the other elements specified in Paragraph (*a*).

Sampling. 4. The sampling shall be carried out in accordance with the procedure for High-Carbon Ferro-Chromium, Chromium Metal, Low-Carbon Ferro-Manganese and Manganese Metal described in the Standard Methods of Sampling Ferro-Alloys (A.S.T.M. Designation: A 103) of the American Society for Testing Materials.[2]

Methods of Chemical Analysis. 5. The chemical analysis shall be carried out in accordance with the procedure for ferro-molybdenum in the Tentative Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum (A.S.T.M. Designation: A 104 - 32 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall St., New York City.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 543.

[3] See p. 641.

Packing. 6. Low-carbon ferro-molybdenum shall be packed in sound containers in such manner that none of the metal is lost in shipment.

Inspection. 7. (*a*) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the sampling, packing and shipping of material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

(*b*) If the purchaser so elects, the material may be sampled by him at the destination, in which case at least 10 per cent of the containers shall be sampled.

Rejection. 8. Any claims or rejections based on check analysis shall be made within 30 days from receipt of material.

TENTATIVE SPECIFICATIONS
FOR
MOLYBDENUM SALTS AND COMPOUNDS[1]

A.S.T.M. Designation: A 146 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover the standard grades of molybdenum salts.

Chemical Composition. 2. (*a*) The material shall conform to the following requirements as to chemical composition:

Molybdenum	30.00 to 45.00 per cent
Sulfur, maximum	0.25 per cent
Phosphorus, maximum	0.10 per cent
Copper, maximum	0.20 per cent

(*b*) The manufacturer shall furnish an analysis of each shipment showing the molybdenum content, and when required such of the other elements specified in Paragraph (*a*).

Packing. 3. Molybdenum salts shall be packed in bags containing 5 lb. of molybdenum content or in other sound containers in quantities as specified. The material furnished under these specifications shall be thoroughly mixed before packing so that the quality in each container is uniform with the lot.

Sampling. 4. The material to be shipped in bags shall be sampled in accordance with the Standard Methods of Sampling Ferro-Alloys (A.S.T.M. Designation: A 103) of the American Society for Testing Materials[2] by the manufacturer at the time the material is being packed. The purchaser shall be privileged to have his representative present during such sampling at the manufacturer's works.

Methods of Chemical Analysis. 5. The chemical analysis shall be carried out in accordance with the Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104) of the American Society for Testing Materials.[3]

Inspection and Rejection. 6. If claim for rejection is to be made, the purchaser shall sample at least 10 per cent of the containers upon arrival of the material at its destination. Any claims or rejections shall be made within 30 days of receipt of the material.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall St., New York City.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 543.

[3] *Ibid.*, p. 547.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF FERRO-TUNGSTEN AND FERRO-MOLYBDENUM[1]

A.S.T.M. Designation: A 104 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

FERRO-TUNGSTEN

DETERMINATION OF TUNGSTEN

See the Determination of Tungsten under Ferro-Tungsten and Tungsten Metal in the Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104) of the American Society for Testing Materials.[2]

NOTES

NOTE 1.—Fuming with perchloric acid can be substituted for fuming with sulfuric acid if desired. In this case, add 10 cc. of perchloric acid (60 per cent) after the treatment with HF and HNO_3 and evaporate to strong fumes of perchloric acid. Cool, add 50 cc. of water, transfer the solution to a 400-cc. beaker and proceed as in the case of sulfuric acid.

NOTE 2.—If the alloy contains molybdenum, the weighed tungsten oxide may contain a few hundredths of a per cent of molybdenum as MoO_3. If extreme accuracy is desired, the oxide should be tested colorimetrically. If the molybdenum content of the alloy is unknown, one of the sodium carbonate extracts of the fused impure WO_3 can be treated with tartaric acid, mineral acid and hydrogen sulfide and then, if appreciable molybdenum is indicated, the amount should be determined in the sodium carbonate extract obtained in the duplicate run.

NOTE 3.—At the best, direct determinations of tungsten in high-grade metal is subject to inherent errors. Accuracy within 0.2 per cent is all that can be expected by any method.

DETERMINATION OF SILICON

Fuse 0.9344 to 1.0416 g. of the sample as described under Determination of Sulfur and Silicon in the Analysis of Ferro-Tungsten and Tungsten Metal in the Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104) of the American Society for Testing Materials.[1] Leach the fusion with water, acidify with HCl and evaporate to dryness and bake at 110° C. Add 20 cc. HCl (sp. gr. 1.19) and warm until all iron salts appear to have dissolved. Add 200 cc. of boiling water and a little paper pulp. Stir well and filter. Wash the tungstic acid thoroughly with hot dilute HCl (1 per cent). Ignite until carbon is gone, add a drop or two of H_2SO_4, evaporate, and then ignite first at a low temperature and finally at 1000 to 1100° C. for 15 to 30 minutes. Cool the ignited WO_3 and SiO_2 and weigh it. Add 5 or 6 cc. of pure HF and a drop or two of dilute H_2SO_4 (1:1), evaporate, and again ignite at 750° C. until constant weight is obtained. The loss in weight, corrected for any SiO_2 in the reagents, multiplied by 100 and divided by the weight of sample taken gives the percentage of silicon.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall St., New York City.

These methods, when adopted as standard, will be added to the present Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104 - 27), 1930 Book of A.S.T.M. Standards, Part I, p. 547.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 567.

DETERMINATION OF SULFUR

Transfer 5 g. of the sample to a 300-cc. platinum dish provided with a platinum cover. Add 100 cc. of HNO_3 (sp. gr. 1.42) and add HF a few drops at a time, while heating, until the alloy has dissolved completely. Rinse and remove the cover. Add 1 g. of $NaNO_3$ and 30 cc. of $HClO_4$ (60 per cent) and evaporate to strong fumes of $HClO_4$. Cool, rinse down with water, and again evaporate to fumes.

Add 100 cc. of water, 10 cc. of cinchonine solution (125 g. of cinchonine, sulfur-free, dissolved in 1 liter of 1:1 HCl) and some ashless paper pulp. Stir well, digest for 15 minutes at 60 to 70° C. and filter. Wash the tungstic acid with hot HCl (2 per cent) containing 10 cc. of cinchonine solution to 1 liter. Precipitate the sulfur as described under Determination of Sulfur in Ferro-Molybdenum.[2]

DETERMINATION OF COPPER, ANTIMONY AND TIN

Mix 5 g. of the finely powdered metal with 25 g. of Na_2O_2 in a 50-cc. iron crucible. Fuse carefully over a free flame by holding the crucible with a pair of tongs and slowly revolving it around the outer edge of the flame until the contents have melted down quietly. Do not raise the temperature rapidly enough to cause spattering. When the charge is molten, keep the crucible at a low red heat and impart a slight rotary motion to stir up any unattacked particles. At the end of 4 to 6 minutes increase the temperature to bright redness for a minute. Cool the crucible with the cover tightly on and as soon as the melt has solidified, tap the still slightly warm crucible several times on an iron plate in order to loosen the melt in a solid cake. Transfer the melt to a 600-cc. beaker, cover, treat with 300 cc. of warm water, rinse the crucible and add the rinsings to the beaker. Heat to boiling, cool somewhat, add 20 g. of tartaric acid and then 50 cc. of dilute H_2SO_4 (1:1). Heat until a clear solution is obtained. If iron scale remains insoluble, decant the liquid, dissolve the scale in strong acid, using a drop of HNO_3 if necessary, and add the solution to the main solution. If unattacked tungsten metal remains, filter, and make a second fusion on the small residue.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 571.

[2] See p. 648.

(*a*) *Separation of Copper from Antimony and Tin.*—Adjust the volume of the solution to a volume of 400 cc., heat to from 65 to 70° C. and pass a rapid stream of H_2S through the solution for 30 minutes. Filter, and wash the precipitated sulfides with dilute H_2SO_4 (5:95) containing about 1 g. of tartaric acid per 100 cc. and saturated with H_2S. Return the paper and sulfides to the beaker in which the precipitation was made and treat with 50 cc. of KOH-K_2S solution (prepared by saturating 1 volume of a 10-per-cent solution of KOH with H_2S and then adding 3 volumes of the solution). Add 1 g. of Na_2O_2 and heat to boiling in the course of 5 minutes and as the solution is occasionally stirred. Dilute with an equal volume of water, filter into a 400-cc. beaker, and wash with a diluted K_2S solution (1:10); reserve the filtrate (*A*).

(*b*) *Copper.*—Dissolve the residue and determine copper colorimetrically or electrolytically as described under Determination of Copper in Ferro-Molybdenum.[1]

(*c*) *Separation of Tin and Antimony.*—Treat the reserved filtrate (*A*) with HCl until the solution is acid and then add 1 ml. per 100 cc. in excess. Filter, and wash with acidulated hydrogen sulfide water. Transfer the paper and sulfides to a 400-cc. beaker, treat with 10 cc. of HCl and add $KClO_3$, a few crystals at a time, as the solution is warmed to from 35 to 40° C. Dilute to 200 cc. and boil gently to expel chlorine. Add 5 g. of oxalic acid, heat to from 60 to 70° C. and pass in a rapid stream of H_2S for 20 to 30 minutes. Filter, and wash thoroughly with hydrogen sulfide water containing 0.5 cc. of sulfuric acid and a few crystals of oxalic acid per 100 cc. Reserve the filter paper and precipitate (*B*) for the determination of antimony.

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[1] See p. 649.

(*d*) *Determination of Tin:*

Standard Solution of Iodine.—Dissolve 3.97 g. of iodine in a solution of 7 g. of KI in a little water. When solution is complete, dilute to 1 liter and mix thoroughly. 1 cc. of the solution should represent approximately 0.00185 g. of tin and the exact titer is found by dissolving 0.02 g. of pure tin in HCl, treating with lead as in the method, and titrating. For the small amounts of tin involved, the theoretical titer as based on standardization against pure arsenious oxide can be used.

Apparatus for Reduction of Tin.—The apparatus for reduction is shown in Fig. 1. At the point *A* a small hole about 1 mm. in diameter shall be blown in the glass. The glass rod *B* shall be drawn out at the end and covered with rubber tubing so as to form a light fitting stopper for the end of the tube *C*.

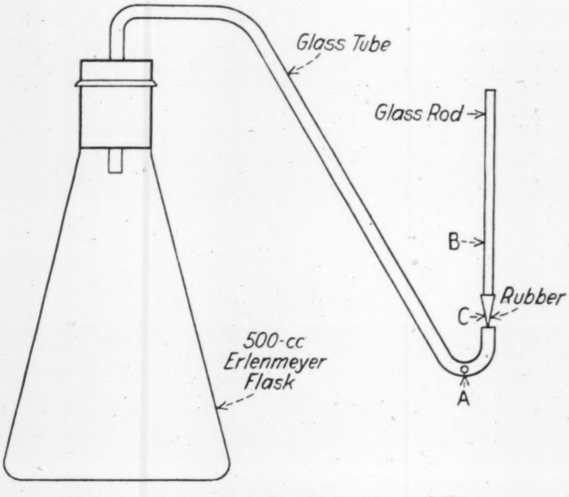

Fig. 1.—Apparatus for Reduction of Tin.

Treat the filtrate with 5 cc. of H_2SO_4 and evaporate to heavy fumes of the acid. Cool somewhat, and dilute with 100 cc. of water. Add 50 cc. of a solution of ferric sulfate (1-per-cent) and heat to boiling. Stir vigorously and add dilute NH_4OH (1:1) until the solution is alkaline and then add 3 to 5 cc. in excess. Let settle, filter, and wash with hot water. Dissolve the precipitate in 80 cc. of hot dilute HCl (1:1) and wash the filter with hot water, collecting the solution (not over 150 cc. in volume) in a 300-cc. Erlenmeyer flask. Add 1 to 2 g. of test lead and close the flask with a one-hole rubber stopper carrying a bent delivery tube, as shown in Fig. 1.

Boil gently for 20 minutes. At the end of this period immerse the end of the delivery tube in a small beaker containing about 50 cc. of a strong solution of $NaHCO_3$ and insert the rubber-tipped tube at *C*, Fig. 1. Remove the flask and beaker from the hot plate and cool in a stream of cold water. When cool, remove the stopper, add 5 cc. of freshly prepared starch solution and titrate with the standard solution of iodine to a permanent blue tint. Subtract the volume required in a blank run and multiply by the tin titer of the solution.

(*e*) *Determination of Antimony:*

Spread the reserved filter paper and precipitate (*B*) side down, on a small watch glass and place this over a beaker containing a few centimeters of HCl and a drop or two of bromine. Warm the beaker until decomposition of the sulfide is complete. Rinse cover and paper with warm dilute HCl (1:9), keeping the volume down to 25 cc. Evaporate the solution to about 5 cc. on the steam bath and then add 1 g. of pure ferrous sulfate, 0.5 g. of potassium chloride, and 40 cc. of HCl. Evaporate the solution on the steam bath to a volume of about 5 cc. Dilute with 10 cc. of water, add 1 cc of HNO_3 and heat until the iron is oxidized. Dilute to 100 cc. heat to boiling, and add dilute NH_4OH until in definite excess. Let settle, filter, and wash with warm water. Dissolve the precipitate in 10 to 15 cc. of hot dilute HCl (1:3) containing 0.1 g. of tartaric acid. Dilute to 100 cc., heat and add ammonium bisulfite drop-by-drop to reduce the iron. Boil to expel the excess of SO_2, cool and pass in a rapid stream of H_2S for 15 to 30 minutes. Filter through a weighed Gooch crucible and wash successively with acidulated hydrogen sulfide water, alcohol, ether and carbon disulfide. Heat in a radiator and add a *drop* of HNO_3, from time to time to oxidize the sulfide. Finally heat at about 600° C. and weigh as Sb_2O_4.

FERRO-MOLYBDENUM

DETERMINATION OF CARBON
BY THE
DIRECT-COMBUSTION METHOD

Determine carbon by the direct-combustion method described in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials[1] with the following modifications:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 318.

1. It is advisable to use a flux such as ingot iron or red lead, particularly with low-carbon alloys. If fluxes are added, great care shall be taken in obtaining a proper correction for the blank.

2. Because of the high sulfur maximum, special provision must be made for the removal of oxides of sulfur in the exit gases. This can be done (*a*) by passing the gases through platinized silica gel heated to 500° C. and then through a column of ironized asbestos; (*b*) by passing through a strong solution of chromic acid or potassium permanganate and then through a desiccant such as magnesium perchlorate; or (*c*) by inserting a 6-in. plug of ironized asbestos in the exit end of the combustion tube and burning out the accumulated sulfate regularly.

SOLUTIONS AND APPARATUS REQUIRED

Ferric Phosphate Solution.—Dissolve 100 g. of ferric sulfate in 1 liter of water to which 150 cc. of phosphoric acid, (sp. gr. 1.73) and 20 cc. of dilute sulfuric acid (1:1) have been added.

Standard 0.1 N Potassium Permanganate.—Prepare and standardize the solution as described in the Standard Methods of Chemical Analysis of Alloy Steels (A.S.T.M. Designation: A 55) of the American Society for Testing Materials.[1] 1 ml. of a 0.1 *N* solution of $KMnO_4$ represents 0.0067 g. of sodium oxalate, and 0.0032 g. of molybdenum.

Jones Reductor.—The reductor should contain a column of 20 to 30-mesh amalgamated zinc $\frac{3}{4}$ in. in diameter and 10 in. in length, resting on enough asbestos to prevent particles of zinc from passing into the receiving flask. To amalgamate the zinc, treat it with a solution of $HgCl_2$ (2 per cent) for a few minutes and then wash thoroughly with water. When idle, the reductor should always be kept full to above the top of the zinc with distilled water.

METHOD

Transfer 0.5 g. of sample to a 150-cc. beaker, cover, treat with 10 cc. of dilute HNO_3 (1:3), and warm to complete solution. If solution is difficult, add a drop or two of HF. When reaction is complete, cautiously add 10 cc. of dilute H_2SO_4 (1:1), and evaporate to fumes of the acid. Cool, add 40 cc. of water and warm. Rinse and remove the cover. Filter and wash the paper and silica 12 to 15 times with hot water, 3 to 4 times with hot dilute NH_4OH (1:3), and finally 4 to 5 times with hot water, the washings being allowed to run into the main filtrate. Discard the silica. Cool, add NH_4OH until it is difficult to avoid a red tint, and heat the still acid solution to boiling. Pour the solution slowly and with vigorous stirring into 75 cc. of nearly boiling dilute NH_4OH (1:5) contained in a 500-cc. beaker. Rinse the beaker with a little water, and then with a little hot dilute NH_4OH and add to the main solution. Add a little paper pulp, filter into a 500-cc. beaker, and wash the residue with hot water. Set the filtrate aside. Dissolve the precipitate in a slight excess of hot dilute H_2SO_4 (1:4), and nearly neutralize and pour into NH_4OH as before. Filter into the reserved filtrate. Dissolve the precipitate and repeat the operation.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 351.

Treat the three combined ammoniacal filtrates with 3 g. of powdered tartaric acid. Stir until dissolved, and saturate the warm solution with H_2S. If a precipitate appears, filter and wash with a dilute solution of $(NH_4)_2S$. Warm the filtrate, cover the beaker, and add dilute H_2SO_4 (1:1) until the solution contains 10 cc. in excess for each 100 cc. of solution. Let the solution stand at the side of the steam bath (about 40° C.) for 15 minutes, and let settle. Filter, and wash the sulfide thoroughly with dilute H_2SO_4 (1:99) containing 10 g. of tartaric acid per liter and saturated with H_2S.

Transfer the MoS_3 and paper to a 250-cc. beaker, cover, and treat with 6 cc. of H_2SO_4 and 10 cc. of HNO_3. Cautiously heat until fumes of H_2SO_4 are given off. Let cool, add 5 cc. of HNO_3, again heat to fumes, and repeat the treatment until the yellow color due to organic matter has disappeared. Cool, rinse and remove the cover, rinse the inside of the beaker, and add a solution of $KMnO_4$ (2.5 per cent) very *cautiously* until a permanent red tint is obtained. Again evaporate to fumes of H_2SO_4. Cool and add 75 cc. of water. Boil for a few minutes, add 2 g. of pure zinc shot (0.002 per cent of iron or under), and continue the boiling until any copper has been reduced to metal. Filter through a filtering crucible and wash with hot water.

If the Jones reductor has been standing idle, pass 100 cc. of warm (40 to 50° C.) dilute H_2SO_4 (5:95) through it, then a little water, and discard the solution. Add 35 cc. of the phosphate solution to the receiver, and then enough water so that the tip of the reductor dips well beneath the solution when the receiver is connected with the reductor. Draw the cool or slightly warm solution of the molybdenum, which should be about 100 cc. in volume and contain about 5 cc. of H_2SO_4, through the reductor as the receiving flask is given slight rotary motion. Just before the surface of the liquid reaches the zinc, add a 50-cc. portion of water, and finally rinse by adding two more portions, each time just before the surface of the solution reaches the zinc. Close the stopcock while a portion of the last washing solution remains in the reductor funnel. Disconnect, and raise the reductor as a little water is allowed to run through the stem, rinse the outside of the stem, and proceed with the titration with the standard 0.1 *N* solution of $KMnO_4$. Run a blank, subtract the volume of 0.1 *N* solution required, and multiply the remainder by the molybdenum titer of the solution.

DETERMINATION OF SULFUR

Transfer 2 to 5 g. of the sample to a 500-cc. casserole and dissolve it in 30 to 75 cc. of HNO_3 (sp. gr. 1.42). The reaction is likely to be very rapid and the acid should be added cautiously to the covered casserole which is preferably kept cooled by immersion in ice water.

Add 30 cc. of HCl (sp. gr. 1.19) and evaporate to dryness on the sand or steam bath. Add 30 cc. more of HCl (sp. gr. 1.19), again evaporate to dryness, and bake for 30 minutes at 105° C. Take up with 25 to 50 cc. of HCl (sp. gr. 1.19) and when solution is complete, dilute with water, and filter to remove silica. Evaporate the filtrate to from 15 to 25 cc. to expel most of the free acid, and dilute to 100 cc. with warm water. Add a little paper pulp, filter, and wash, first with dilute HCl (1:99) and then with water. Dilute to 200 cc., add 20 cc. of a solution of $BaCl_2$ (10 per cent), and stir vigorously for several minutes. Allow to stand overnight and filter on a paper of close texture. Wash the paper and $BaSO_4$, 18 to 20 times with cold HCl (1 per cent), 3 or 4 times with NH_4OH (5 per cent) to remove ammonium phosphomolybdate, ignite and weigh. A blank should be run on all reagents used.

DETERMINATION OF PHOSPHORUS

Dissolve 2 g. of the finely ground sample in 20 cc. of HNO_3, (sp. gr. 1.42) and 20 cc. of HCl (sp. gr. 1.19). Add 20 cc. of dilute H_2SO_4 (1:1) and evaporate to fumes of sulfuric acid. Cool somewhat, add 75 cc. of dilute HCl (1:5), heat nearly to boiling and filter. Wash the filter with hot dilute HCl (1:5) and dilute the filtrate and washings to 250 cc. Add NH_4OH in slight excess, heat to boiling, boil for 1 to 2 minutes, and let the precipitate settle. Filter through 11-cm. paper of loose texture and wash the precipitate with hot water. Discard the filtrate. Dissolve the precipitate in 25 cc. of hot dilute

HCl (1:1) and reprecipitate with NH_4OH. Filter, wash a few times with hot water, and discard the filtrate. Dissolve the precipitate in 100 cc. of hot dilute HNO_3 (1:3), catching the filtrate in a 300-cc. Erlenmeyer flask. From this point proceed as in the Determination of Phosphorus by the Alkalimetric Method in Ferro-Manganese in the Standard Methods of Chemical Analysis of Ferro-Alloys (A.S.T.M. Designation: A 104) of the American Society for Testing Materials.[1]

DETERMINATION OF COPPER

Transfer 5 g. of sample to a 400-cc. beaker and dissolve in a slight excess of dilute HNO_3 (1:3), adding a few drops of HF if solution is difficult. Cautiously add 25 cc. of H_2SO_4 (sp. gr. 1.84), and evaporate to fumes of sulfuric acid. Cool, treat with 150 cc. of water, filter into a 400-cc. beaker, and wash the residue with water. Nearly neutralize with NaOH and pour into 100 cc. of a warm solution of NaOH (10 per cent). Filter, and discard the filtrate. Dissolve the precipitate in warm, dilute H_2SO_4 (1:3) and repeat the precipitation and filtration. Dissolve the precipitate in warm, dilute H_2SO_4 (1:3). Cool and treat with 3 g. of powdered tartaric acid. When this has dissolved, add NH_4OH till slightly alkaline, then dilute H_2SO_4 (1:1) till just acid, and finally 2 cc. in excess. Add 5 g. of Na_2SO_3, heat nearly to boiling and, slowly and with stirring, add a solution of 1 g. of KCNS in as little water as possible. Add a little paper pulp and digest with occasional stirring for 30 minutes at about 90° C. Filter and wash thoroughly with hot water containing a little tartaric acid and KCNS. Ignite paper and residue in a porcelain crucible at about 700° C. Brush the residue into a 100-cc. electrolysis beaker, add 5 cc. of HNO_3 to the crucible, warm for a few minutes, and pour into the beaker. Heat until the oxide has dissolved and evaporate to 1 to 2 cc. Add 50 cc. of water and determine the copper by electrolysis (see the Determination of Copper in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials[2] if the amount is high, or by the colorimetric method[3] if the amount is small.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 552.

[2] *Ibid.*, p. 339.

[3] *Ibid.*, p. 340.

TENTATIVE METHODS OF TEST
FOR
MAGNETIC PROPERTIES OF IRON AND STEEL[1]

A.S.T.M. Designation: A 34 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Definitions

For standard tests of normal induction, hysteresis and core loss as outlined in the following sections, these definitions will apply.[2]

Definitions. 1. (*a*) *Magnetizing Force* (*Magnetic Force, Magnetic Intensity*), *H*.—The space rate of variation of magnetomotive force at any point in the magnetic circuit.

UNIT: *Oersted.*

NOTE.—At the center of an infinitely long solenoid having n turns per centimeter in which a current of I amperes is flowing, $H = 0.4\ \pi nI$.

(*b*) *Normal Induction, B*.—The induction in a magnetic material corresponding to a given magnetizing force when the material is in a symmetrically cyclic magnetic condition with respect to the given magnetizing force.

UNIT: *Gauss.*

(*c*) *Normal Permeability*, μ.—The ratio of the normal induction to the corresponding magnetizing force.

$$\text{Normal Permeability} = \frac{\text{Normal Induction (gausses)}}{\text{Magnetizing Force (oersteds)}}$$

(*d*) *Normal Residual Induction.*—The magnetic induction which remains in a magnetic material when the effective magnetizing force has been reduced to zero from a point on the normal induction curve.

(*e*) *Coercive Force*, H_c.—The magnetizing force that is just sufficient to reduce the induction in a material to zero, starting from a point on the normal induction curve.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

These methods are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Methods of Test for Magnetic Properties of Iron and Steel (A.S.T.M. Designation: A 34 - 28), 1930 Book of A.S.T.M. Standards, Part I, p. 396.

[2] These definitions are identical with those in the extensive list of definitions appearing in the Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A.S.T.M. Designation: A 127 - 31 T), see *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 696 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 219.

(*f*) *Core Loss* (*Iron Loss*), *W*.—The power expended in a magnetic material subjected to a varying induction.

(*g*) *Standard Core Loss*, $W_{B/f}$.—The total power in watts consumed in each kilogram of material at a temperature of 25° C. when subjected to an alternating magnetizing force so as to produce a variable induction varying harmonically between specified limits of $+B$ and $-B$ and of frequency f. Unless otherwise specified, the maximum induction shall be 10 kilogausses and the frequency 60 cycles per second. This shall be represented by the symbol $W_{10/60}$.

NOTE.—If the loss corresponding to a higher induction is desired, the sample should be subjected to a harmonically varying induction having a maximum of 14 kilogausses. The corresponding symbol will be $W_{14/60}$.

(*h*) *Core Loss Aging Coefficient*.—The percentage change in the standard core loss after continued heating at 100° C. for 600 hours. The sign shall be positive if there is an increase in loss.

A. Normal Induction and Hysteresis

TEST SPECIMENS

Test Specimens.

2. (*a*) Test specimens may consist of rings, straight bars or strips of uniform cross-section.

(*b*) Ring specimens shall be continuous, having no joints or welds. The ratio of mean diameter to radial width shall be not less than 10.

(*c*) Sharp shears or dies shall be used in the preparation of specimens of sheet material. If the radial width of ring specimens or the width of straight strips of sheet material is less than 3 cm. ($1\frac{3}{16}$ in.) the punching or cutting strains shall be removed before testing by an annealing process acceptable to both manufacturer and purchaser.

(*d*) Test specimens of sheet material shall consist of straight strips, one half of which shall be cut parallel and the other half at right angles to the direction of rolling, and in types of test requiring companion samples each half shall contain an equal number of each kind of strips.

Size of Specimens.

3. (*a*) Test specimens of sheet material shall have a cross-sectional area of not less than 2 sq. cm. (0.31 sq. in.) nor more than 4 sq. cm. (0.62 sq. in.) and shall be so selected from not less than two sheets that their properties shall represent as nearly as practicable the average properties of the sheets. (See Fig. 1).

(*b*) The cross-section of specimens of sheet material shall be calculated from measured values of length and mass and measured or assumed values of density.

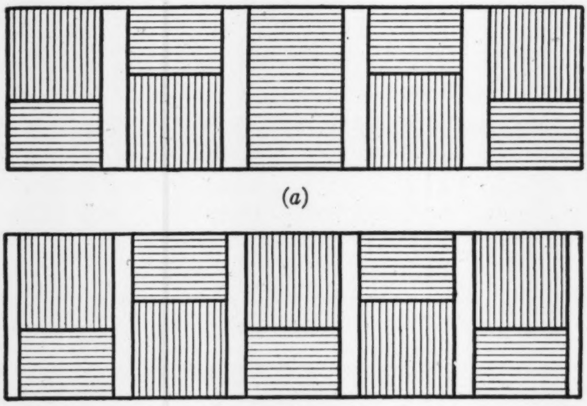
(*c*) For silicon steels, a density of 7.7 g. per cu. cm. shall be assumed if the silicon content is 2 per cent or less and a density of

7.5 g. per cu. cm. shall be assumed if the silicon content is over 2 per cent.

(*d*) For nickel-iron alloys the density shall be assumed from the nickel content as given by the straight lines joining the points defined as follows:[1]

NICKEL, PER CENT	DENSITY, G. PER CU. CM.
0	7.85
30	8.00
100	8.90

(*e*) For other alloys, a density corresponding to the actual measured or estimated value shall be used.



(*a*)

(*b*)

FIG. 1.—Suggested Distribution of Strips to be Cut from Sheets for Magnetic Tests.

Magnet Steel Specimens. 4. Specimens of magnet steel shall be hardened and aged previous to testing in accordance with a procedure acceptable to both manufacturer and purchaser.

STANDARD DATA

Standard Data. 5. (*a*) The standard normal induction data for all magnetic materials shall consist of corresponding values of normal induction and magnetizing force at suitable intervals within the range of values agreed upon by the manufacturer and purchaser.

(*b*) Normal residual induction and coercive force values for transformer core material and material of the type used for electromagnet cores shall be determined from a maximum normal induction of 10 kilogausses.

(*c*) For permanent magnet steel, the residual induction and coercive force shall be determined from the maximum normal induction corresponding to a magnetizing force of 300 oersteds, unless from a maximum magnetizing force of 300 oersteds the coercive force is 100 oersteds or more, in which case the maximum magnetizing force shall be 1000 oersteds.

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[1] For 50 per cent nickel content the density is 8.26 g. per cu. cm. For 80 per cent nickel content the density is 8.64 g. per cu. cm.

METHODS OF TESTING

Methods of Testing.

6. The tests may be made by means of one of the following methods:

(*a*) *The Rowland Ring Method.*—This method may be used for any magnetizing forces obtainable without excessive heating. It is not recommended for hardened material, such as permanent magnet steel, on account of the effect of residual strains due to hardening.

(*b*) *The Burrows Compensated Double Yoke.*—This type of apparatus is suitable for tests at magnetizing forces up to 300 oersteds. For higher magnetizing forces, serious difficulty due to heating may be encountered unless special temperature control is provided. The magnetizing coils shall be not less than 20 cm. ($7\frac{7}{8}$ in.) in length and the ratio of the area of the test coil to that of the specimen shall be such that the air correction factor shall be not greater than 5. This air correction may be applied by calculation or eliminated by means of an adjustable mutual inductor, having its primary in series with the main permeameter magnetizing winding and its secondary in series with the main test coil. This inductor shall be set to such a value that the flux in the space between the sample and the test coil shall be automatically compensated for. If desired, the two main magnetizing coils may be connected in series and the average values for the whole sample determined by connecting the two middle test coils in series and using them as one. In this arrangement, four auxiliary test coils near the ends of the specimens are connected in series and used as one coil for adjusting the current in the compensating magnetizing coils.

(*c*) *The Fahy Simplex Permeameter.*—This type of apparatus is suitable for tests at magnetizing forces up to 300 oersteds without difficulties due to heating.

(*d*) *Isthmus Method.*—This method, as described in U. S. Bureau of Standards *Scientific Papers Nos. 361* and *383*, is suitable for tests at magnetizing forces exceeding 100 oersteds.

(*e*) *Babbitt* (or *J*) *Permeameter.*—This type of apparatus is suitable for tests at magnetizing forces from 40 oersteds to 1000 oersteds if care is taken to prevent excessive heating.

(*f*) *Simplex High Magnetization Adapter.*—This type of apparatus may be used for the determination of maximum induction, B_m, residual induction, B_r, and coercive force, H_c, of high coercive force materials with the following reservations: B_m and B_r results are sufficiently accurate for commercial tests, assuming uniform specimens; H_c may be low by an amount depending on the thickness of specimen and magnitude of H_c. These errors may vary from 0 to 10 or 12 per cent, the error generally being greater as the thickness of the specimen increases.

ACCURACY

Accuracy. 7. (*a*) The accuracy of the results of magnetic tests depends not only upon the method or apparatus used, but also upon the nature of the specimen. The most common sources of error are (1) lack of uniformity in permeability along the length of the specimen, (2) mechanical strain, and (3) temperature variations. Errors due to these causes are indeterminate and may be large.

(*b*) For specimens having a satisfactory degree of uniformity, clamped so as to be free from mechanical strain and kept at a constant temperature within 5° C., the methods specified in Section 6 may be expected to give the following accuracy: For normal induction, the values of magnetizing force corresponding to inductions up to an induction equal to two-thirds of that corresponding to the maximum magnetizing force specified in Section 5 (*c*) should be accurate within 3 per cent, provided the permeability does not exceed 10,000. This permeability limitation does not apply to the ring method. Values of induction greater than the above should be accurate within 1 per cent. For residual induction, values should be accurate within 2 per cent and for coercive force within 5 per cent, except as noted in Section 6 (*f*) for the Simplex Adapter.

(*c*) For magnetically non-uniform material the accuracy specified in Paragraph (*b*) cannot be obtained with the Burrows permeameter. The Fahy Simplex permeameter and the Babbitt permeameter, each within its proper range, give values more nearly representative of the average properties of non-uniform material with an accuracy estimated to be approximately within the limits specified in Paragraph (*b*).

NOTE.—See R. L. Sanford and J. M. Barry, "Determination of the Magnetic Induction in Sheet Steel," U. S. Bureau of Standards *Scientific Paper No. 545*, February 17, 1927.

B. Core Loss

TEST SPECIMENS

Test Specimens. 8. (*a*) The test sample shall be cut from two or more sheets taken at random from shipment. It is recommended that a test sample shall represent not more than 5000 kg. (11,000 lb.).

The test specimens shall be distributed symmetrically over the sheet, as nearly as may be practicable. (See Fig. 1.).

The test specimens shall be cut with sharp shears and shall be 50 cm. (19$\frac{11}{16}$ in.) in length and 3 cm. (1$\frac{3}{16}$ in.) in width.

(*b*) Place on the balance a pile of test specimens weighing 2.5 kg. Add a second pile of the same kind, bringing the weight up to 5 kg. In each case the weight shall be taken to the nearest specimen. Add in succession two piles of 2.5 kg. each, of the other kind of specimens, bringing the weight up to 7.5 kg. and 10 kg. respectively. Care should be taken to keep separate the specimens which are cut at different directions of the grain.

Notes.—1. If desired, for convenience, the bundles may be loosely secured by tape or string (not wire).

2. If desired, a 5-kg. specimen may be used for routine acceptance tests, provided it is cut from at least two sheets, except in case of a dispute between the manufacturer and purchaser in which case the 10-kg. specimen shall be used.

Apparatus

Apparatus. 9. (*a*) The magnetizing winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and joined in series. A secondary coil shall be used for energizing the voltmeter and the potential coil of the wattmeter.

These solenoids shall be wound on a form of any non-magnetic, non-conducting material of the following dimensions:

Inside cross-section	4 by 4 cm.
Thickness of wall	not over 0.3 cm.
Winding length	42 cm.

The primary winding on each solenoid shall consist of 150 turns of copper wire uniformly wound over the 42-cm. length. The total resistance of the magnetizing winding shall be between 0.3 and 0.5 ohm. The secondary winding of 150 turns of copper wire on each solenoid shall be similarly wound beneath the primary winding. Its resistance shall not exceed 1 ohm.

(*b*) A voltmeter and the voltage coil of a wattmeter shall be connected in parallel to the terminals of the secondary winding of the apparatus. The current coil of the wattmeter shall be connected in series with the primary winding. A low power factor wattmeter shall be used.

Test Procedure

Procedure. 10. The standard core loss shall be measured under the following conditions:

(*a*) The magnetic circuit shall consist of 10 kg. (22 lb.) of the test material, one-half parallel and one-half at right angles to the direction of rolling, made up into four equal bundles, two containing material parallel and two containing material at right angles to the direction of rolling, and finally built into the four sides of a square with butt joints and opposite sides consisting of material cut in the same manner. No insulation other than the natural scale of the material (except in the case of scale-free material) shall be used between laminations, but the corner joints may be separated by tough paper approximately 0.1 mm. (0.004 in.) in thickness.

(*b*) An electromotive force having a wave form approximating a sine curve shall be applied to the primary winding and adjusted until the voltage of the secondary circuit is that determined by the equation:

$$E = \frac{4 f N n B M}{4 l D 10^5}$$

where f = form factor of primary e.m.f. = 1.11 for sine wave
N = number of secondary turns = 600
n = number of cycles per second = 60
B = maximum induction, kilogausses = 10 kilogausses
M = total mass in grams = 10,000 g.
l = length of strips in centimeters = 50 cm.

$$D = \text{density, grams per cubic centimeter} = \begin{cases} 7.5 \text{ g. per cu. cm. for high-resistance steel} \\ 7.7 \text{ g. per cu. cm. for low-resistance steel} \end{cases}$$

$$E = \begin{cases} 106.6 \text{ volts for high-resistance steel for sine voltage} \\ 103.8 \text{ volts for low-resistance steel for sine voltage} \end{cases}$$

NOTE.—For the 14-kilogauss test the voltages will be as follows:

$$E = \begin{cases} 149.2 \text{ volts for high-resistance steel for sine voltage} \\ 145.2 \text{ volts for low-resistance steel for sine voltage} \end{cases}$$

The form factor of the applied electromotive force shall not vary more than 1 per cent from the value of 1.11. If desired, an average voltmeter can be substituted for or used in conjunction with the r.m.s. voltmeter.

NOTE.—See G. Camilli, "A Flux Voltmeter for Magnetic Tests," *Journal* Am. Inst. Electrical Engrs., Vol. 45, p. 989, October, 1926; also B. M. Smith and C. Concordia, "Measuring Core Loss at High Densities," *Electrical Engineering,* Vol. 51, No. 1, January, 1932.

As an alternative to the use of a sine wave, the correct value of the voltage may be determined by applying it to an Epstein apparatus containing a sample of similar material which has been standardized by means of a sine wave electromotive force. The wattmeter is brought to the correct reading for the standard sample. The corresponding voltage is the correct one to use. This alternative method may be modified by comparing standard and test samples by means of a differential wattmeter. For this test, the secondary voltage needs to be only approximately correct. When using these comparison methods, the form factor of the induced voltage wave should not differ from 1.11 by more than 5 per cent.

(*c*) For silicon steels, a density of 7.7 g. per cu. cm. shall be assumed if the silicon content is 2 per cent or less and a density of 7.5 g. per cu. cm. shall be assumed if the silicon content is over 2 per cent.

(*d*) For nickel-iron alloys the density shall be assumed from the nickel content as given by the straight lines joining the points defined as follows:[1]

NICKEL, PER CENT	DENSITY, G. PER CU. CM.
0	7.85
30	8.00
100	8.90

(*e*) For other alloys a density corresponding to the actual measured or estimated value shall be used.

11. (*a*) Apply the alternating voltage to the primary coil and tap the joints together until the current has a minimum value, as shown by an ammeter in series. Then clamp the corners firmly by some suitable device.

(*b*) Shunt the ammeter and adjust the primary current until the voltmeter indicates the proper value. This adjustment may be made by an auto-transformer, by varying the field of the alternator, or by both, but not by the insertion of resistance or inductance in the primary circuit. Simultaneously, the frequency shall be adjusted to 60 cycles.

(*c*) Read the wattmeter when the voltage and frequency are correct.

(*d*) The wattmeter gives the power consumed in the iron and the secondary circuit. The loss in the secondary circuit is given in terms of the total resistance and voltage. This loss $= \frac{E^2}{R}$; where E is the secondary r.m.s. voltage and R is the parallel resistance of the voltmeter and the shunt circuit of the wattmeter. Subtract from the wattmeter reading the loss in the secondary circuit, which will be constant for any set of instruments and voltage, and divide by the weight of sample in kilograms. The result is the standard core loss.

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[1] For 50 per cent nickel content the density is 8.26 g. per cu. cm. For 80 per cent nickel content the density is 8.64 g. per cu. cm.

C. *Alternating-Current Tests at Low Inductions*

Scope. 12. These methods provide for the determination of the alternating-current permeability and core loss of magnetic materials at low inductions. These properties are indicative of the effect of the material on the impedance and loss characteristics of apparatus in which the core materials are worked at low inductions.

Standard Values. 13. Tests shall be made either at a frequency of 60 cycles per second or at 1000 cycles per second. Standard values at 60 cycles per second are those corresponding to a maximum induction of 10 gausses or 1000 gausses according to the use for which the material is intended. At 1000 cycles per second, the standard values are those corresponding to a maximum induction of 10 gausses.

NOTE.—Apparatus often operates under conditions in which the alternating magnetization is superposed upon a steady unidirectional magnetization, but it is not necessary to introduce this complication into the standard tests, as the relative quality of materials is adequately indicated by the simple alternating-current tests.

TEST SPECIMENS

Test Specimens. 14. Test specimens shall consist of not less than 1 kg. (2.2 lb.) of the test material cut with sharp shears into strips 25 cm. ($9\frac{27}{32}$ in.) in length and 3 cm. ($1\frac{3}{16}$ in.) in width, one half parallel and one half at right angles to the direction of rolling, made up into four equal groups, two containing material parallel and two containing material at right angles to the direction of rolling. The four groups shall then be assembled in the test coils to form a square with the corners so arranged that at each corner consecutive layers mutually overlap the butt joints occurring in each single layer. The opposite sides of the square shall consist of material cut in the same manner.

Insulation of Test Specimens. 15. When testing for core loss, the separate laminations shall be effectively insulated from one another.

METHODS OF TEST

16. (*a*) The tests may be made either by the bridge method as shown in Fig. 2 and specified in Sections 17 and 18 or by the alternating-current potentiometer method as shown in Fig. 3 and specified in Sections 20 and 21.

(*b*) *Power Supply.*—The supply voltage shall be of approximately a sine wave form, having not more than 10 per cent of total harmonics present.

(*c*) *Test Winding.*—The test winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and connected in series. These solenoids shall be wound on forms of any non-magnetic, non-conducting material of the following dimensions:

Inside cross-section	3.2 by 1 cm.
Thickness of wall	not over 0.3 cm.
Winding length	17 cm.

The winding on each solenoid shall consist of 25 turns of insulated copper wire uniformly wound over the 17-cm. length. The total resistance shall not exceed 0.5 ohm. For the alternating-current potentiometer method, 100 turns shall be uniformly wound on each solenoid and connected in series to form a secondary winding of 400 turns.

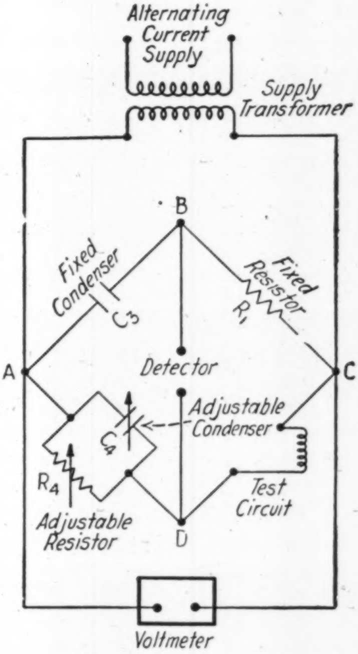
Alternating Current Supply
Supply Transformer
B
Fixed Condenser
C_3
Fixed Resistor
R_1
A
C
Detector
Adjustable Condenser
C_4
R_4
Adjustable Resistor
Test Circuit
D
Voltmeter

FIG. 2.—Diagram Showing Apparatus and Connections for Bridge Method.

Apparatus for Bridge Method:

17. The apparatus shall consist of the following (see Fig. 2): **Apparatus, Bridge Method.**

(*a*) *Voltmeter.*—Any voltmeter capable of indicating the voltage supplied to the bridge at the test frequency with an accuracy of at least ± 2 per cent may be used. A multi-range vacuum-thermocouple type instrument is recommended.

(*b*) *Fixed Condenser.*—The fixed condenser, C_3 ,shall be a high-grade mica condenser of 1.0 microfarad ± 0.25 per cent capacitance having a power factor of not more than 0.0015 at 1000 cycles per second.

(*c*) *Adjustable Condenser.*—The adjustable condenser, C_4, shall be a four-decade condenser having steps of $10 \times (1.0 + 0.1 + 0.01 + 0.001)$ microfarads adjusted to an accuracy of ± (0.25 per cent + 50 micro-microfarads). The units decade may be made with high-grade paper condensers having a power factor not more than 0.006 at 1000 cycles per second. The other decades shall be made with mica condensers having a power factor of not more than 0.0015 at 1000 cycles per second.

(*d*) *Fixed Resistor.*—The fixed resistor, R_1, shall be a non-reactive resistor of 10 ohms ± 0.1 per cent, with a time constant not to exceed one microsecond.[1]

(*e*) *Adjustable Resistor.*—The adjustable resistor, R_4, shall be a four-decade non-reactive resistor having steps of $10 \times (1000 + 100 + 10 + 1)$ ohms adjusted to an accuracy of ± (0.1 per cent + 0.05 ohms) with a time constant not to exceed one microsecond.[1]

(*f*) *Detector.*—Any zero-current detector having the necessary sensitivity may be used. For the 60-cycle test, a vibration galvanometer is recommended while for the 1000-cycle test a telephone receiver is recommended. A single stage vacuum tube amplifier preceding the galvanometer or receiver is recommended when it is necessary to increase the sensitivity.

(*g*) *Supply Transformer.*—The supply transformer, T, shall be a suitable transformer providing efficient and distortionless inductive coupling and substantial electrostatic isolation between the source of supply and the bridge network.

Procedure for Bridge Method:

Procedure, Bridge Method.

18. (*a*) The test specimen shall be thoroughly demagnetized before testing.

(*b*) Set the voltage, E, to give the desired induction in accordance with the relation:

$$E = 0.0707\,AB$$

where B = the maximum induction in gausses, and

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[1] Time constant is defined as the inductance in henries divided by the resistance in ohms, or the shunt capacitance in farads multiplied by the resistance in ohms.

A = the cross-sectional area of the specimen in square centimeters calculated from values of length, mass and specific gravity.

NOTE.—Values of specific gravity may be assumed in accordance with Section 10 (*c*) and (*d*) or may be experimentally determined.

Adjust R_4 and C_4 to balance the bridge. Then:

$$\mu = \frac{7.95\, R_4}{A}$$

and the loss:

$$W = E^2 \left[C_4 \omega^2 10^{-5} - R_{DC} \left(\frac{1}{R_4^2} + C_4^2 \omega^2 \right) \right]$$

where W = the total loss in watts;
A = the cross-section in square centimeters;
C_4 = the value of adjustable condenser in farads;
ω = 2π times the frequency in cycles per second;
R_{DC} = the resistance of winding in ohms; and
R_4 = the value of adjustable resistor in ohms.

NOTE.—W divided by the mass in kilograms gives the loss in watts per kilogram.

Apparatus for the Potentiometer Method:

Apparatus, Potentiometer Method.

19. The apparatus shall consist of the following (see Fig. 3):

(*a*) *Alternating-Current Potentiometer.*—The alternating-current potentiometer shall be of the coordinate type, indicating voltage in terms of two components having a quadrature phase relation. A suitable phase shifting device shall be provided to adjust the phase of either the potentiometer supply or the magnetizing current.

(*b*) *Resistance.*—The resistance, R, shall be a non-inductive resistance of such a value as to give a potential drop of suitable magnitude. For an induction of 10 gausses, a resistance of 100 ohms is recommended. For an induction of 1000 gausses, a resistance of 1 ohm would be suitable. The resistances should be adjusted to an accuracy of ± 0.1 per cent, with a time constant not to exceed one microsecond.

Procedure for Potentiometer Method:

Procedure, Potentiometer Method.

20. (*a*) The test specimen shall be thoroughly demagnetized before testing.

(*b*) Throw the switch, S (Fig. 4), so as to connect the potentiometer to the secondary winding and adjust the phase so that the total voltage is read on the in-phase dial, the quadrature dial being set to zero. Set the voltage E to give the desired induction in accordance with the relation:

$$E = \sqrt{2}\,\pi f N A B \times 10^{-8}$$

which for 60 cycles per second reduces to:

$$E_{60} = 0.00107\,A\,B$$

and for 1000 cycles per second is:

$$E_{1000} = 0.0178\,A\,B$$

where the symbols have the same significance as in Section 18;

f = frequency in cycles per second, and
N = 400 turns.

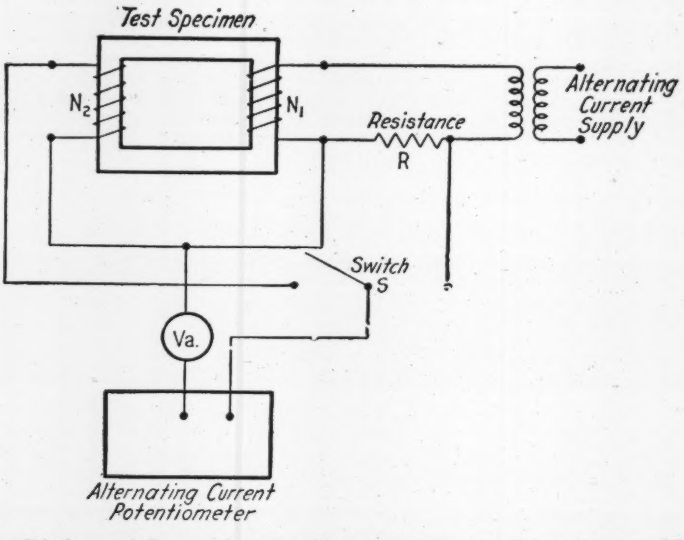

FIG. 3.—Diagram of Connections for Alternating-Current Potentiometer Method.

Throw switch S to connect the potentiometer to the resistance, R, and read the voltage. The power component is then indicated by the in-phase voltage and the magnetizing component is indicated by the quadrature voltage. The corresponding values of current are obtained by dividing the voltage by the resistance R. Denoting the in-phase and quadrature currents by I_P and I_Q respectively:

$$\mu = 0.563\,\frac{B}{I_Q}$$

and

$$W = \frac{E\,I_P}{4}$$

where the symbols have the same significance as in Section 18.

NOTE.—W divided by the mass in kilograms gives the loss in watts per kilogram.

TENTATIVE SPECIFICATIONS

FOR

FIRE-REFINED COPPER OTHER THAN LAKE[1]

A.S.T.M. Designation: B 72 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1932.[2]

Scope.

1. (*a*) These specifications cover fire-refined copper, other than Lake, and not usually electrolytically refined.

(*b*) Fire-refined copper, other than Lake, is intended for use in rolling into sheets and shapes for mechanical purposes and is not intended for electrical purposes nor wrought alloys.

CHEMICAL PROPERTIES

Chemical Composition.

2. The copper in all shapes shall conform to the following requirements as to chemical composition:

Copper plus silver, minimum	99.7000	per cent
Arsenic, maximum	0.1000	"
Antimony, maximum	0.0120	"
Bismuth, maximum	0.0020	"
Iron, maximum	0.0100	"
Lead, maximum	0.0100	"
Nickel, maximum	0.1000	"
Oxygen, maximum	0.0750	"
Selenium, maximum	0.0400	"
Tellurium, maximum	0.0140	"
Tin, maximum	0.0500	"

Chemical Analysis.

3. The chemical analysis shall be made in accordance with the Standard Methods of Battery Assay of Copper (A.S.T.M. Designation: B 34) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, 7016 Euclid Ave., Cleveland, Ohio.

[2] Revision accepted by Committee E-10 on Standards, August 11, 1932.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 776.

PHYSICAL DEFECTS

Physical Defects. 4. Wire bars, cakes, slabs and billets shall be substantially free from shrink holes, cold sets, sloppy edges, concave tops, and similar defects in set or casting. This requirement shall not apply to ingots or ingot bars, in which case physical defects are of no consequence.

PERMISSIBLE VARIATIONS IN WEIGHT AND DIMENSION

Permissible Variations. 5. A permissible variation of plus or minus 5 per cent in weight or plus or minus $\frac{1}{4}$ in. in any dimension from the manufacturer's published list or the purchaser's specified size shall be considered good delivery; provided, however, that wire bars may vary in length plus or minus 1 per cent from the listed or specified length, and the cakes may vary plus or minus 3 per cent from the listed or specified size.

MARKING

Marking. 6. All wire bars, cakes, slabs and billets shall be stamped with the manufacturer's brand and furnace charge mark. Ingots and ingot bars shall have a brand stamped or cast in, but need have no furnace charge mark.

LOTS

Lots. 7. The manufacturer shall arrange the car loads or lots so that, when possible, each shall contain shapes from but one furnace charge in order to facilitate testing by the purchaser.

CLAIMS

Claims. 8. Claims, to be considered, shall be made in writing within thirty days of receipt of the material at the purchaser's plant and results of the tests made by the purchaser shall accompany such claims. The manufacturer shall be given one week from the date of receipt of the complaint to investigate his records, and shall then either agree to satisfy the claim or send a representative to the purchaser's plant. No claims shall be considered if the material in question, unused, cannot be shown to the manufacturer's representative.

Claims against quality will be considered as follows:

(*a*) Metal contents by furnace charges, ingot lots, or ingot-bar lots.

(*b*) Physical defects by individual pieces.

(*c*) Variations in weight or dimension by individual pieces.

Inspection. 9. (*a*) The manufacturer's representative shall inspect all pieces where physical defects or variations in weight or dimension are claimed. If agreement is not reached, the question of fact shall be submitted to a mutually agreeable umpire, whose decision shall be final.

(*b*) In a question of metal contents each party shall select three shapes from the consignment or lot to be investigated. These shapes shall be sampled in the presence of both parties by drilling five holes approximately ½ in. in diameter at points equally spaced between the ends of each piece. Bars, billets, ingots and ingot bars shall be sampled along a center line, while slabs and cakes shall be sampled along a diagonal line projecting between opposite corners. The drillings shall be made from top to bottom and completely through each piece. Scale from set and any surface dirt shall be rejected. No lubricant shall be used and the drilling shall not be forced sufficiently to cause oxidation of the chips. In the case of shapes having a depth greater than 5 in., drillings may be made from both the top and bottom for a depth not less than 2 in. in each direction instead of completely through the shape, but the drilling shall be otherwise conducted as before described. **Investigation of Claims.**

The resulting sample shall be cut up, thoroughly mixed and separated into three equal portions, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire, if necessary.

Each party shall make an analysis in accordance with Section 3 and if the results do not establish or dismiss the claim to the satisfaction of both parties concerned, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact and whose determination shall be final.

10. The expenses of the refiner's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. **Settlement of Claims.**

In the case of rejection being established, the damage shall be limited to payment of freight both ways by the refiner for substitution of an equivalent weight of copper conforming to these specifications.

TENTATIVE SPECIFICATIONS

FOR

HARD-DRAWN COPPER TRANSMISSION CABLE[1]

A.S.T.M. Designation: B 87 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover bare concentric-lay cables of nineteen strands or less composed of copper wires laid helically about an axis in one or more layers.

MANUFACTURE

Material. 2. The copper from which the wires are manufactured shall conform in quality and purity to the requirements for wire bars in the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (A.S.T.M. Designation: B 4) or, Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (A.S.T.M. Designation: B 5) of the American Society for Testing Materials.[2]

Joints and Brazes. 3. The wires shall be continuous throughout the length of the cable. No splices, joints or brazes will be permitted in any wire after final drawing.

Pitch. 4. The pitch of the outer strands of the cable shall be not less than twelve nor more than sixteen times the diameter of the cable. The pitch of the inner strands of 12-strand and 19-strand cable shall be that required for 3-strand and 7-strand cable composed of the same size wires.

Lay. 5. The outer wires of the cable shall have left-hand lay unless otherwise specified by the purchaser. The lay of the inner wires shall be opposite to that of the outer strands.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part I, pp. 573 and 578, respectively.

PHYSICAL PROPERTIES AND TESTS

Wire Size, Tensile Strength and Elongation.

6. (*a*) Except as noted in Section 7, the composition of the cables and the physical characteristics of the component wires after stranding shall conform to the following requirements:

SIZE, A.W.G.	AREA, CIRCULAR MILS	NUMBER OF WIRES	DIAMETER OF WIRES, MILS MAXIMUM	DIAMETER OF WIRES, MILS MINIMUM	TENSILE STRENGTH OF WIRES, MINIMUM, LB. PER SQ. IN.	ELONGATION IN 10 IN., MINIMUM, PER CENT
3	52 630	3	133.7	131.1	58 400	1.45
2	66 370	3	150.3	147.3	57 100	1.50
1	83 690	3	168.7	165.3	56 200	1.55
0	105 500	7	124.0	121.6	58 600	1.45
00	133 100	7	139.3	136.5	57 900	1.45
000	167 800	7	156.3	153.3	57 100	1.55
0000	211 600	12	134.1	131.5	58 400	1.45
....	250 000	12	145.6	142.8	57 900	1.50
....	300 000	12	159.6	156.4	57 100	1.55
....	350 000	19	137.2	134.4	57 900	1.45
....	400 000	19	146.6	143.6	57 100	1.50
....	450 000	19	155.5	152.5	57 100	1.55
....	500 000	19	163.7	160.5	57 100	1.55

Variation in Tensile Strengths.

(*b*) The variation in tensile strengths of the wires in any given cable length (exclusive of the soft or annealed core) shall not exceed 5000 lb. per sq. in.

Core.

7. Unless otherwise specified, 19-strand cable shall be made with a soft or annealed copper core having the same diameter as the other wires in the cable. This soft or annealed wire shall have a tensile strength of not more than 37,000 lb. per sq. in. nor less than 31,000 lb. per sq. in. and a minimum elongation in 10 in. of 30 per cent.

Test Samples.

8. Tests for determining the physical and electrical properties of the wires shall be made on samples taken from the cable after stranding.

Preparation of Samples.

9. The wires in the sample shall be unlaid and straightened carefully by hand or by tapping with a soft wood, rawhide, or fiber hammer on a rawhide, or other suitable block. The individual wires then shall be marked with gage marks 10 in. apart.

Tensile Strength Tests.

10. All tensile strength determinations shall be made by operating the testing machine at a speed such that the beam may be kept accurately in balance at all times.

Elongation.

11. (*a*) Elongation shall be defined as the percentage permanent increase in length due to breaking of the wire in tension measured between gage marks, originally 10 in. apart, placed upon the wire.

(*b*) The fracture shall be between the gage marks and not closer than 1 in. to either gage mark.

(*c*) The elongation shall be obtained by measuring carefully the increased distance between gage marks after carefully fitting the fractured portions together.

ELECTRICAL PROPERTIES AND TESTS

Electrical Resistivity. 12. (*a*) The resistivity of each wire (exclusive of the soft or annealed core) shall not exceed 902.27 lb. per mile ohm at a temperature of 20° C. (68° F.). The resistivity of the soft or annealed core shall not exceed 884.08 lb. per mile ohm at a temperature of 20° C. (68° F.).

(*b*) The electrical resistivity shall be determined by resistance measurements.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Finished Lengths. 13. The finished cable lengths shall not vary more than 5 per cent over or under the lengths specified on the order.

Variation in Area. 14. The area of cross-section of the completed cable as determined by weight shall be not more than 2 per cent under the area specified.

Density. 15. For purposes of calculating weights, cross-sections, etc., the density of copper shall be taken as 8.89 g. per cu. cm. at 20° C. (68° F.).

FINISH

Finish. 16. The wires shall be cylindrical in form, closely stranded and free from scales, splints and all other surface imperfections not consistent with the best commercial practice.

PACKING AND MARKING

Packing. 17. Cables shall be packed and shipped on reels. Drums of reels shall have diameters such that the cable will not be injured by bending. In no case shall the diameter be less than 24 in. for cable No. 0000 A.w.g. and smaller and not less than 27 in. for cable 250,000 circular mils and larger. Each reel shall be of good material, substantially constructed and, unless otherwise specified, shall be completely lagged with heavy lumber so that the cable will not be damaged in handling or shipping. The heads of reels shall be so designed and sufficiently rugged that the cable may be handled in the field without damage to the reel. The holes in the heads of reels shall be circular and 2½ in. in diameter.

Steel reels if well constructed and satisfactory to the purchaser may be used in lieu of wood reels.

Marking. 18. The net weight, length, size, kind of cable, purchase order number and any other marks required by the purchaser's order shall be included on a tag attached to the end of the cable inside of the reel. The same information together with the manufacturer's serial number and all shipping marks required by the purchaser shall appear on the outside of each reel.

INSPECTION

Inspection. 19. All tests prescribed by these specifications shall be made at the factory by the purchaser's representative or by the manufacturer under the supervision of the purchaser's representative and all apparatus, instruments and material for the purpose shall be furnished by the manufacturer without charge to the purchaser.

Access to Factory. 20. Material furnished under these specifications shall be subject to inspection by the purchaser's representative during all stages of manufacture. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the cable ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the cable is being furnished in accordance with these specifications.

Manufacturer's Obligations. 21. Neither the inspection nor waiving of inspection nor the purchaser's acceptance shall relieve the manufacturer from his obligation to furnish material in strict accordance with these specifications.

TENTATIVE SPECIFICATIONS
FOR
SAND CASTINGS OF THE ALLOY: COPPER 80 PER CENT; TIN 10 PER CENT; LEAD 10 PER CENT[1]

A.S.T.M. Designation: B 74 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1932.[2]

Scope. 1. (*a*) These specifications cover alloy castings, the alloy being a composition of copper, tin and lead, known commercially as 80-10-10, deoxidized with phosphorus.

(*b*) The castings are intended for use for bearings and bushings in the cast state. This alloy is frequently used also for castings which are called upon to resist some of the mild acids such as are found in mine waters.

MANUFACTURE

Process. 2. (*a*) The alloy may be made by any approved method.

(*b*) The castings shall be of uniform quality.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. (*a*) The alloy shall conform to the following requirements as to chemical composition:

	MINIMUM	DESIRED	MAXIMUM
Copper, per cent	77	79.25	....
Tin, per cent	9	10	11
Lead, per cent	9	10	11
Zinc, per cent	0.25	0.75	1
Phosphorus, per cent	....	....	0.01
Antimony, per cent	....	....	0.50
Iron, per cent	....	....	0.25
Nickel, per cent	....	....	0.50
Sulfur, per cent	....	....	0.08
Aluminum, per cent	....	....	none[a]
Silicon, per cent	....	....	0.03
Total constituents, other than copper, lead, tin, zinc, nickel and antimony, per cent	....	....	0.50

[a] The term "none" as applied to aluminum allowance is defined as a maximum of 0.005 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

[2] Revision accepted by Committee E-10 on Standards, August 11, 1932.

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

Chemical Analysis. 4. (*a*) An analysis of each melt may be made at the option of the purchaser and at his own expense.

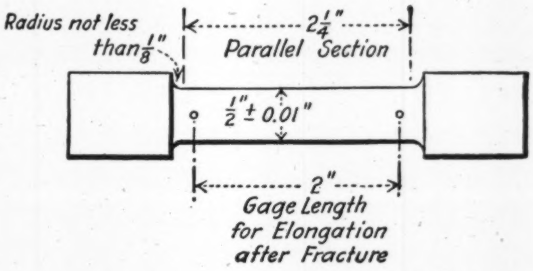
(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 5. (*a*) The alloy shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	25 000
Yield point, lb. per sq. in.	12 000
Elongation in 2 in., per cent	6

(*b*) The yield point shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1—Standard 2-in. Gage Length Test Specimen.

(*c*) Castings made from this alloy shall conform to such requirements as to pressure tests as may be mutually agreed upon between the manufacturer and the purchaser and as specified in the contract or purchase order.

Tension Test Specimens. 6. (*a*) The tension test specimen shall be machined from a coupon to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*b*) The coupon attached to the casting shall be in accordance with the dimensions shown in Fig. 2. The fin gate along the side shall not be less than $\frac{5}{16}$ in. in thickness at any point along its length.

Number of Tests. 7. (*a*) Each casting weighing 250 lb. or more shall have, if practicable, at least one test coupon attached. The responsibility of furnishing sufficient test specimens shall rest with the manufacturer.

(*b*) In the case of castings weighing less than 250 lb. each, at least one test coupon shall, if practicable, be attached to one or more castings from each melt or heat or from such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings.

(*c*) In the case of castings where, in the opinion of the inspector, it is impracticable to attach a test coupon to the casting, bars shall be cast separately in sand. At least one test bar shall be poured from each melt or heat of metal, or such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings. The bars shall be cast from the first metal poured from the heat, and the inspector shall witness the pouring of the test mold.

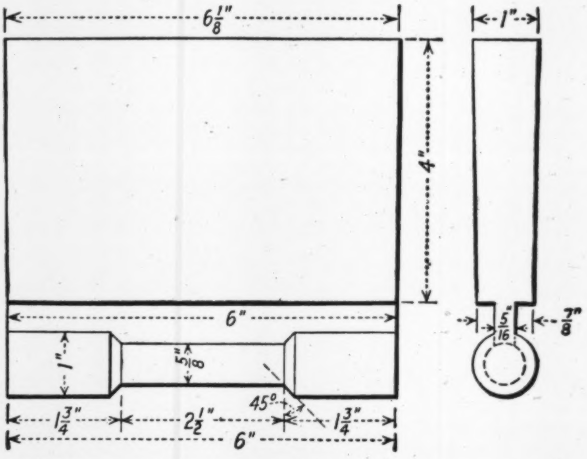


FIG. 2.—Test Specimen Coupon.

(*d*) If any test specimen shows defective machining or reveals casting defects, it may be discarded and replaced by another specimen selected by the inspector. If additional test coupons are not available, the replacement specimen may be taken from the body of a casting selected by the inspector to represent the lot.

WORKMANSHIP AND FINISH

Finish. 8. (*a*) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector.

(*b*) The castings shall not be repaired, plugged, welded, or "burned in" unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment.

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set.

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

MARKING

Marking.

9. The castings shall be marked with pattern or mark number and, when practicable, with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

INSPECTION AND REJECTION

Inspection.

10. (*a*) Inspection may be made at the manufacturer's works or at the point of delivery. Inspection is optional with the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS
FOR
COPPER-BASE ALLOYS IN INGOT FORM FOR SAND CASTINGS[1]

A.S.T.M. Designation: B 30 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued as Tentative, 1919; Adopted in Amended Form, 1922;
Reissued as Tentative, 1928; Revised, 1930, 1931, 1932.[2]

Scope.

1. These specifications cover copper-base alloys in ingot form for sand castings in twenty different compositions, regularly sold by the trade and arbitrarily herein given numbers 1 to 20, inclusive, to differentiate them from one another. These numbers have no other significance.

MANUFACTURE

Quality.

2. The manufacturer shall use care to have each lot of ingot metal as uniform in quality as possible. This metal may be manufactured by any refining process which will yield a satisfactory quality of product.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. The alloys shall conform to the requirements as to chemical composition given in Table I, within the limits specified therein.

NOTE.—The limits specified in Table I indicate the maximum and minimum percentages within which variations of different elements shall be permitted, with the understanding that every precaution shall be taken both in the selection of raw materials as well as methods of manufacture to insure that the resulting ingot metal will come within these specified limits.

Samples for Chemical Analysis.

4. (*a*) Ten ingots shall be selected by the inspector to represent each 40,000 lb. and five ingots shall be selected for less than carload lots.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Chase Brass and Copper Co., Inc., Waterbury, Conn.

These tentative specifications are, in effect, a revision of the former Standard Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (A.S.T.M. Designation: B 30 - 22), which specifications were discontinued in 1928

[2] Latest revision accepted by Committee E-10 on Standards, August 11, 1932.

(*b*) The samples for chemical analysis may be taken by drilling the ingots and shall represent the average cross-section of all of the ingots selected for sampling.

TABLE I.—CHEMICAL COMPOSITIONS OF COPPER-BASE ALLOYS.

	Copper, per cent		Tin, per cent			Lead, per cent			Zinc, per cent				Other Elements, maximum, per cent						Total Constituents, per cent	
Alloy Grade	Minimum	Desired	Minimum	Desired	Maximum	Minimum	Desired	Maximum	Minimum	Desired	Maximum	Phosphorus, maximum, per cent	Antimony	Iron	Nickel	Sulfur	Aluminum[a]	Silicon	Other than Copper, Lead, Tin, Zinc and Nickel	Other than Copper, Lead, Tin, Zinc, Nickel and Antimony
BRONZE ALLOYS																				
No. 1	87	89	5.5	6	6.5	1.5	2	2.5	2	3	4	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 2	84	85	9	10	11	1.5	2	2.5	1.5	2	2.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 3	84	85	7.25	8	8.75	1.5	2	2.5	3.5	4	4.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
RED BRASS ALLOYS																				
No. 4	84	85	4.5	5	5.5	4.5	5	5.5	4.5	5	5.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 5	83	85	4.25	5	5.75	4.25	5	5.75	4.25	5	5.75	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 6	82	83	6.25	7	7.75	6.25	7	7.75	2	3	...	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
SEMI RED BRASS ALLOYS																				
No. 7	83	84	2.5	3	3.5	2.5	3	3.5	9	10	11	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 8	82	83	3.25	4	4.75	5	6	7	5	7	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 9	79	80	2.5	3	3.5	6.25	7	7.75	7.5	9.5	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 10	77	78	2.5	3	3.5	4.25	5	5.75	11	13.5	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
YELLOW BRASS ALLOYS																				
No. 11	70	71	1	1.5	2	2	3	4	20	24	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 12	67	69	0	0	1.5	2	3	4	25	27	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 13	64	66	0	0	1	1	2	3	30	31	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 14	60	62	0	0	1	1	2	3	30	35	...	0.01	0.10	0.30	0.50	0.05	0.50	0.10	1.00	....
HIGH LEAD ALLOYS																				
No. 15	84	85	4.25	5	5.75	8	9	10	0.5	1	2	0.01	0.25	0.25	0.50	0.08	none	0.03	....	0.50
No. 16	79	80	9	10	11	9	10	11	...	...	0.50	0.05[b]	0.50	0.25	0.25	0.08	none	0.03	....	0.50
No. 17	77	79.25	9	10	11	9	10	11	0.25	0.75	1	0.01	0.50	0.25	0.50	0.08	none	0.03	....	0.50
No. 18	72	73	7	8	9	13.5	15	16.5	1	1.5	2	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50
No. 19	71	71.5	3.5	4.5	5.5	14	17	20	2	4	6	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50
No. 20	70	70.5	5.25	6	6.75	18	20	22	0.5	1	1.5	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50

[a] The term "none" as applied to Aluminum allowance is defined as a maximum of 0.005 per cent when determined in accordance with Section 5.

[b] Minimum

(*c*) The drill used shall be thoroughly cleaned. No lubricant shall be used in the operation and the drillings shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis. 5. The chemical analysis shall be made in accordance with the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45) of the American Society for Testing Materials.[1]

Marking. 6. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the alloy shall be marked on each ingot for identification.

INSPECTION AND REJECTION

Inspection. 7. (*a*) Inspection may be made at the manufacturer's works, where the ingots are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 8. If the test ingots selected to represent a lot fail to conform to the requirements specified in Section 3 all ingots in such lot shall be rejected.

CLAIMS

Claims. 9. Claims, to be considered, shall be made in writing within 30 days of receipt of material at the purchaser's plant and the results of the purchaser's tests shall be given. The manufacturer shall, within one week of receipt of such claim, either agree to satisfy the claim, or send a representative to the purchaser's plant to resample the shipment in accordance with Section 4. Samples so taken shall be sealed and submitted to a mutually agreeable umpire whose determinations shall be final.

Settlement of Claims. 10. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of ingot metal conforming to these specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 837.

APPENDIX

The data in the following tables do not constitute a part of these specifications. They are given merely to indicate to the purchaser the approximate physical properties of the various alloys specified, that may be expected of carefully manufactured alloys of the formulas indicated and to constitute a guide to the purchaser in selecting the alloy grade best suited for meeting the service conditions for which the ingot metal is to be used.

Alloy Grade	Tensile Strength,[a] lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent	Compression Deformation Limit,[b] lb. per sq. in.	Brinell Hardness (500 kg. for 30 seconds)	Pattern Maker's Allowance for Shrinkage, in. per ft.	Weight, lb. per cu. ft.
BRONZE ALLOYS							
No. 1	30 000 to 40 000	15 to 30	15 to 30	......	44 to 48	0.1875	535
No. 2	32 000 to 38 000	15 to 20	15 to 20	......	55 to 65	0.1875	535
No. 3	30 000 to 36 000	25 to 30	25 to 30	......	55 to 65	0.1875	535
RED BRASS ALLOYS							
No. 4	27 000 to 33 000	15 to 20	15 to 20	......	50 to 60	0.1875	535
No. 5	27 000 to 33 000	15 to 20	15 to 20	......	50 to 60	0.1875	535
No. 6	26 000 to 32 000	13 to 19	14 to 21	......	50 to 60	0.1875	540
SEMI RED BRASS ALLOYS							
No. 7	31 000 to 37 000	25 to 35	20 to 30	......	50 to 60	0.1875	535
No. 8	29 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	535
No. 9	22 000 to 28 000	10 to 15	10 to 15	......	50 to 55	0.1875	540
No. 10	25 000 to 30 000	15 to 25	20 to 25	......	45 to 55	0.1875	540
YELLOW BRASS ALLOYS							
No. 11	30 000 to 35 000	35 to 45	25 to 35	......	40 to 50	0.1875	535
No. 12	30 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	535
No. 13	30 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	533
No. 14	30 000 to 45 000	15 to 25	20 to 30	......	40 to 50	0.250	500
HIGH LEAD ALLOYS							
No. 15	25 000 to 31 000	8 to 13	7 to 13	12 000	45 to 55	0.1875	540
No. 16	27 000 to 33 000	7 to 12	8 to 13	12 500	47 to 52	0.1875	553
No. 17	27 000 to 33 000	7 to 10	7 to 12	12 500	47 to 52	0.1875	553
No. 18	25 000 to 30 000	11 to 17	10 to 16	12 000	45 to 50	0.1875	570
No. 19	25 000 to 30 000	10 to 15	7 to 13	12 000	47 to 52	0.1875	570
No. 20	22 000 to 27 000	10 to 16	7 to 13	11 000	42 to 47	0.1875	570

[a] The tension tests were made on test specimens taken from ingots, except Alloys Nos. 7 and 15, which were sand cast. Sand-cast test specimens would show somewhat lower values.

[b] The compression tests were made on machined test specimens (sand castings) of 1 sq. in. sectional area, 1 in. high. The compression deformation limit is taken as the load producing a compression in the specimen of 0.001 in.

Alloy Grade	Examples of Use	Foundry Manipulation	Characteristics
	Bronze Alloys		
No. 1	For valves and fittings for steam, gas, etc	Requires careful foundry practice	Machines well
No. 2	Commercial bronze for high-duty bearings where wear resistance is essential	Requires careful foundry practice	Machines well
No. 3	Good-strength hard bronze for general service	Requires careful foundry practice	Machines well
	Red Brass Alloys		
No. 4	High-grade red brass for general service	Foundry practice not difficult	Machines well
No. 5	Second-grade red brass for general service	Foundry practice not difficult	Machines well
No. 6	Auto fittings, carburetor parts	Foundry practice not difficult	Machines well
	Semi Red Brass Alloys		
No. 7	Catenary fittings, overhead fittings Electric Railways; very resistent to atmospheric corrosion	Foundry practice not difficult	Machines well
No. 8	Reddish yellow alloy for air, gas and water fittings	Foundry practice not difficult	Machines well
No. 9	Valve fittings for low pressure	Foundry practice not difficult	Machines well
No. 10	Yellowish red alloy for air, gas and water fittings	Foundry practice not difficult	Machines well
	Yellow Brass Alloys		
No. 11	Yellowish red alloy for plumbers' fittings	Foundry practice not difficult	Machines well
No. 12	Yellow brass for light castings and ornamental work not requiring strength or subjected to internal pressure	Foundry practice not difficult	Machines well
No. 13	Yellow brass for heavier castings	Foundry practice not difficult	Machines well
No. 14	Plumbers' flanges, scupper pipes, etc	Very difficult. Aluminum up to 0.30 per cent improves casting properties, but increases shrinkage	Hard to machine. Not suitable for bearings or water pressure fittings
	High Lead Alloys		
No. 15	Small bearings such as automobile bearings and bushings, machined by broaching	Foundry practice not difficult	Machines easily
No. 16	Bearings for heavy pressure. Not machined by broaching	Foundry practice not difficult	Machines easily
No. 17	Hard bearing metal for small bushings, to be machined by broaching, harder than No. 15	Foundry practice not difficult	Machines easily
No. 18	Locomotive engine castings and general service bearings for moderate pressure	Foundry practice not difficult	Machines easily
No. 19	Car journal bearings and similar service	Foundry practice not difficult	Machines easily
No. 20	Bearings operated at high speed and under light or medium pressure	Foundry practice not difficult	Machines easily

TENTATIVE SPECIFICATIONS
FOR
SEAMLESS COPPER TUBING, BRIGHT ANNEALED[1]

A.S.T.M. Designation: B 68 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927; REVISED, 1930, 1932.

Scope. 1. These specifications cover annealed copper tubing suitable for use in refrigerators, oil lines, gasoline lines, etc., where tubing absolutely free from scale and dirt is required.

MANUFACTURE

Process. 2. The tubing shall be made from copper that has been de-oxidized.

3. The tubing shall be bright annealed after the last drawing operation or after the coiling, if coiling is required.

4. The tubing shall be thoroughly recrystallized and have an average grain size not exceeding 0.040 mm. in diameter.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 5. The material shall conform to the following requirements as to chemical composition:

Copper, minimum	99.90 per cent
Phosphorus, maximum	0.10 per cent

Sampling. 6. The sample for chemical analysis shall consist of drillings, millings or clippings, taken from each lot of 5000 lb. or fraction thereof, and shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Physical Properties. 7. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	30 000
Elongation in 2 in., per cent	40

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

(*b*) The material shall be capable of expanding on a hardened and ground, tapered steel pin having an included angle of 60 deg., to the following amount:

OUTSIDE DIAMETER, IN.	EXPANSION OF OUTSIDE DIAMETER, PER CENT
Up to 1, inclusive	40
Over 1	30

(*c*) Five test specimens shall be selected for physical test from each lot of 5000 lb. or fraction thereof.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Dimensional Variations. 8. The mean inside and outside diameters and the wall thickness of the tubing shall not vary more than the following amounts from that specified:

MEAN INSIDE AND OUTSIDE DIAMETERS, IN.	PERMISSIBLE VARIATIONS, IN.
Up to 1, inclusive	±0.0025
Over 1 to 2, inclusive	±0.003

WALL THICKNESS STUBBS GAGE NO.	IN.	PERMISSIBLE VARIATIONS, IN.
Under 14 to 17, inclusive	0.082 to 0.058, inclusive	±0.004
Under 17 to 20, inclusive	0.057 to 0.035, inclusive	±0.003
Under 20 to 23, inclusive	0.034 to 0.025, inclusive	±0.0025
Under 23	Under 0.025	±0.0025

No combination of variations on the same tube shall make the thickness of the wall vary from the nominal thickness by more than these amounts.

Lengths. 9. The lengths of the tubing, when measured at a temperature of 68° F. (20° C.) shall not vary from that specified on the purchase order by more than the following amounts:

FOR STRAIGHT LENGTHS

ORDERED LENGTH, FT.	PERMISSIBLE VARIATIONS, IN. MINUS	 PLUS
Up to 8, inclusive	0	$\frac{1}{16}$
Over 8 to 15, inclusive	0	$\frac{1}{8}$
Over 15 to 20, inclusive	0	$\frac{3}{16}$

FOR COILS

ORDERED LENGTH, FT.	PERMISSIBLE VARIATIONS, IN. MINUS	 PLUS
Up to 10	0	2
Over 10 to 20, inclusive	0	3
Over 20 to 40, inclusive	0	6
Over 40 to 80, inclusive	0	12
Over 80	0	24

WORKMANSHIP AND FINISH

Workmanship and Finish. 10. The finished tubing shall be smooth, free from interior and exterior mechanical imperfections, and shall have a clean, bright appearance.

PACKING AND MARKING

Packing. 11. The tubing shall be packed in such a manner as to prevent damage in ordinary handling and transportation.

Terms of Rejection. 12. All boxes, bundles, or barrels shall bear the following information: purchase order number, manufacturer's name, size and kind of material, and part number, if any.

REJECTION

Marking. 13. Material failing to comply with the above specifications may be rejected and returned for replacement or full credit at the option of the purchaser.

TENTATIVE SPECIFICATIONS
FOR
COPPER WATER TUBE[1]

A.S.T.M. Designation: B 88 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover seamless copper tubes especially designed for plumbing purposes, underground water services, etc., but also suitable for copper coil water heaters, fuel oil lines, gas lines, etc.

Classes. 2. There shall be three classes of copper water tube, depending on the principal uses as follows:

Class A.—Designed for underground services and general plumbing purposes;

Class B.—Designed for general plumbing purposes; and

Class C.—Designed for use with soldered fittings only.

MANUFACTURE

Material. 3. The tubes shall be made from copper free from cuprous oxide, as determined by microscopic examination at a magnification of 75.

Treatment. 4. (*a*) Class A and B tubes when furnished in coils shall be annealed after coiling.

(*b*) Class A and B tubes when furnished in straight lengths shall normally be hard drawn, but may be furnished with a light temper if so specified.

(*c*) Class C tubes shall be furnished in straight lengths, hard drawn.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 5. The copper shall have a purity of at least 99.90 per cent as determined by electrolytic assay, silver being counted as copper.

Sampling. 6. The sample for chemical analysis shall consist of drillings, millings, or clippings, taken from the tubes selected for purpose of tests, as specified in Section 13, equal quantities being taken from each tube and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committe B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

PHYSICAL PROPERTIES AND TESTS

Tensile Strength.

7. (*a*) Specimens of full cross-section and suitable length shall show the requirements as to tensile properties shown in Table I.

Grain Size.

(*b*) A microscopic examination of specimens from tubes selected for purpose of tests shall show complete recrystallization with uniform grain sizes as shown in Table I.

TABLE I.—TENSILE STRENGTH AND GRAIN SIZE REQUIREMENTS.

		Nominal Temper	
	Annealed	Light Temper[a]	Hard Drawn
Tensile strength, lb. per sq. in., minimum	30 000	32 000	48 000
Tensile strength, lb. per sq. in., maximum	.....	40 000	.....
Elongation in 4 in., minimum, per cent	25	.....	.....
Mean grain size, mm	0.025 to 0.075	.....	.....

[a] This temper may be obtained either by a light draft or light anneal.

Hammering Test.

8. (*a*) Specimens 4 in. in length cut from the ends of the tube selected for purpose of tests shall be hammered flat so that the inside surfaces are completely in contact; and the ends of this flattened specimen shall stand hammering down hot or cold to a knife edge without showing signs of cracks.

(*b*) Specimens from hard-drawn tubes shall be annealed previous to the hammering test.

Opening Test.

9. (*a*) Specimens 3 in. in length cut from each tube selected for purpose of tests shall, when split, stand opening out flat without showing cracks or flaws.

(*b*) Specimens from hard-drawn tubes shall be annealed previous to the opening test.

Bend Test.

10. (*a*) Full sections of tubes representing material furnished annealed shall stand being bent cold to radii shown in the following table without collapsing. In making this test the tube shall be carefully handled and bent around a form of the specified radius:

	Radius of Bend, in.	
Nominal Diameter, in.	Class A	Class B
3/8	3	4
1/2	4	6
3/4	6	9
1	10	15
1 1/4	14	20
1 1/2	20	30
2	30	40

(*b*) Tubes ordered hard drawn will not be required to meet the bend test.

Expansion Test.

11. (*a*) A specimen of suitable length cut from each tube selected for purpose of tests shall be expanded on a tapered pin having an included angle of 90 deg., until the outside diameter has been increased to the amounts shown in the following table without showing cracks or flaws:

NOMINAL SIZE, IN.	DIAMETER AFTER FLANGING, IN.
$\frac{3}{8}$	$\frac{23}{32}$
$\frac{1}{2}$	$\frac{7}{8}$
$\frac{3}{4}$	$1\frac{3}{16}$
1	$1\frac{1}{2}$
$1\frac{1}{4}$	$1\frac{25}{32}$
$1\frac{1}{2}$	$2\frac{1}{16}$
2	$2\frac{5}{8}$

(*b*) Specimens from hard-drawn tubes will not be required to meet the expansion test.

Hydrostatic Test.

12. Each tube selected for purpose of tests shall stand, without showing weakness or defects, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 lb. per sq. in., calculated from the following formula for thin hollow cylinders under tension. No tube shall be tested beyond a hydrostatic pressure of 1000 lb. per sq. in., unless so specified.

$$P = \frac{2\,tS}{D}$$

where P = the hydrostatic pressure in pounds per square inch;
t = the wall thickness in inches;
D = the outside diameter of the tube in inches; and
S = the allowable unit stress of the material = 6000 lb. per sq. in.

Number of Tests.

13. (*a*) A number of tubes equivalent to 0.5 per cent of the shipment shall be selected at random for purpose of tests specified in Sections 7 to 12 inclusive. One hammering, one opening, one bend, and one expansion test shall be made on each such tube selected, except where waived on hard-drawn tubes.

(*b*) In the case of tubes furnished in 30 to 60-ft. coils, a length of approximately 5 to 10 ft., as necessary, shall be cut from each coil selected for purpose of tests. The remaining portion of such coils shall be included in the shipment and length tolerances on such shall be waived.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Weight. 14. The standard weight of any tube shall be based upon the assumption that one cubic inch of the material weighs 0.323 lb.

Dimensions. 15. The standard dimensions for the various nominal sizes, together with diameter and wall thickness tolerances and nominal weights per foot, are given in Table II.

TABLE II.—STANDARD DIMENSIONS, WEIGHTS. AND DIAMETER AND WALL THICKNESS TOLERANCES.
(All tolerances plus and minus.)

Nominal Size, in.	Actual Outside Diameter, in.	Permissible Variation in Mean Outside Diameter, in		Wall Thickness, in.						Weight per Foot, lb.		
				Class A		Class B		Class C				
		Annealed	Hard Drawn	Nominal	Permissible Variation	Nominal	Permissible Variation	Nominal	Permissib Variation	Class A	Class B	Class C
$\frac{3}{8}$	0.500	0.0025	0.001	0.049	0.004	0.035	0.0035	0.025	0.0025	0.269	0.198	0.144
$\frac{1}{2}$	0.625	0.0025	0.001	0.049	0.004	0.040	0.0035	0.028	0.0025	0.344	0.285	0.203
$\frac{3}{4}$	0.875	0.003	0.001	0.065	0.0045	0.045	0.004	0.032	0.003	0.641	0.455	0.328
1	1.125	0.0035	0.0015	0.065	0.0045	0.050	0.004	0.035	0.0035	0.839	0.655	0.464
$1\frac{1}{4}$	1.375	0.004	0.0015	0.065	0.0045	0.055	0.0045	0.042	0.0035	1.04	0.884	0.681
$1\frac{1}{2}$	1.625	0.0045	0.002	0.072	0.005	0.060	0.0045	0.049	0.004	1.36	1.14	0.94
2	2.125	0.005	0.002	0.083	0.005	0.070	0.005	0.058	0.0045	2.06	1.75	1.46
$2\frac{1}{2}$	2.625	0.005	0.002	0.095	0.005	0.080	0.005	0.065	0.0045	2.92	2.48	2.03
3	3.125	0.005	0.002	0.109	0.005	0.090	0.005	0.072	0.0045	4.00	3.33	2.68
$3\frac{1}{2}$	3.625	0.005	0.002	0.120	0.005	0.100	0.005	0.083	0.005	5.12	4.29	3.58
4	4.125	0.005	0.002	0.134	0.006	0.110	0.005	0.095	0.005	6.51	5.38	4.66
5	5.125	0.005	0.002	0.148	0.006	0.125	0.006	0.109	0.005	8.96	7.61	6.65
6	6.125	0.005	0.002	0.165	0.006	0.140	0.006	0.120	0.005	11.96	10.20	8.77

Length. 16. (*a*) The nominal length for tubes furnished straight shall be 20 ft.

(*b*) The nominal lengths for tubes furnished in coils shall be 30, 45, and 60 ft.

Permissible Variations. 17. (*a*) No combination of variations on the same tube shall make the thickness of the wall vary from the nominal thickness by more than the amount specified in Table II.

(*b*) No single tube shall vary in weight by more than 5 per cent from the theoretical weight per foot values given in Table II.

(*c*) Tubes shall not be less than the nominal length.

WORKMANSHIP AND FINISH

Workmanship and Finish. 18. Tubes shall be clean and free from cracks, seams, slivers, scale, and other surface defects.

INSPECTION AND REJECTION

Inspection. 19. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tube is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Retests. 20. When the tubes are finished, and ready for shipment, the inspector shall make the tests to govern the acceptance of the tubes. If any specimen fails to meet the requirements of Sections 7 to 12 inclusive, two additional specimens may be taken, each of which shall conform to the requirements specified.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-COPPER-MAGNESIUM-MANGANESE ALLOY BARS, RODS AND SHAPES[1]

A.S.T.M. Designation: B 89 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

MANUFACTURE

Manufacture.

1. No scrap shall be used in the manufacture of the material except such as may accumulate in the manufacturer's own plants from material of similar composition and of his own manufacture.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

2. The composition of the material as determined by chemical analysis shall conform to the following requirements:

Aluminum, minimum, per cent	92.0
Copper, per cent	3.5 to 4.5
Magnesium, per cent	0.2 to 0.75
Manganese, per cent	0.4 to 1.0

Chemical Analysis.

3. Samples for chemical analysis shall be taken from a random piece representing each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser. Samples may be taken from tension or bend test specimens. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the material. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire if necessary.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

Table II.—Dimensions and Permissible Variations of Alloy Bars, Rods and Shapes.

Cold Finished Rounds, Squares, Hexagons and Octagons; also Rectangles up to 2.75 in. in Width, Provided Area is not Greater than 3 sq. in.

Diameter or Distance Across Flats, in.	Tolerance, in., plus or minus		
	Rounds	Squares, Hexagons, Octagons	Rectangles
Up to 0.064	0.001	0.0015	0.0015
0.065 to 0.500	0.0015	0.002	0.002
0.501 to 1.000	0.002	0.0025	0.0025
1.001 to 1.500	0.0025	0.003	0.003
1.501 to 2.75	......	......	0.005

Rolled Rod

Diameter, in.	Tolerance, in.	
	Plus	Minus
0.375 to 1.500	0.015	0.015
1.501 to 3.499	0.008	0.008
3.500 to 5.000	$\frac{1}{32}$	$\frac{1}{64}$
5.001 to 8.000	$\frac{1}{16}$	$\frac{1}{32}$

Rolled Bar (Including Squares, Hexagons, Octagons and Rectangles)

Least Distance Across Flats, in.	Tolerance, in., plus or minus
Up to 0.500	0.006
0.501 to 0.750	0.008
0.751 to 1.000	0.012
1.001 to 2.000	0.016
2.001 to 3.000	0.020
Width (of Rectangles), in.	
Up to 1.500	$\frac{1}{64}$
1.501 to 4.000	$\frac{1}{32}$
4.010 to 6.000	$\frac{3}{64}$
6.001 to 10.000	$\frac{1}{16}$

Structural Shapes, Rolled

Overall dimensions	±$2\frac{1}{2}$ per cent of nominal dimensions
Thickness	±0.010 in.

Shapes, Extruded

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.125, inclusive	0.010
0.126 to 0.500, inclusive	0.015
0.501 to 1.000, inclusive	0.020
1.001 to 2.000, inclusive	0.025
2.001 to 3.000, inclusive	0.030
3.001 to 4.000, inclusive	0.035
4.001 to 5.000, inclusive	0.045
5.001 and over	0.060

Rounds, Squares, Rectangles, Hexagons, Octagons, Bars and Rods, Extruded

Dimensions, in.	Tolerance, in., plus or minus
Up to 0.500	0.007
0.501 to 1.000	0.010
1.001 to 2.000	0.012
2.001 to 3.000	0.015
3.001 and over	0.018

Permissible Variations in Length

Diameter or Distance Across Flats, in.	Tolerance, in.
Up to 2	$+\frac{1}{8}$
Over 2 to 10	$+\frac{1}{4}$

PHYSICAL PROPERTIES AND TESTS

Temper and Tensile Strength. 4. The material shall be supplied in the temper specified in the contract or purchase order and shall conform to the requirements as to tensile properties for the specified temper as shown in Table I.

TABLE I.—PHYSICAL PROPERTIES OF ALLOY BARS, RODS AND SHAPES.

SECTION	DIAMETER OR DISTANCE ACROSS FLATS, IN.	TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.	YIELD STRENGTH, MINIMUM, LB. PER SQ. IN.	ELONGATION, MINIMUM, PER CENT[a]
		ANNEALED		
All sections......	Up to 10 in...............	35 000 max.	.....	16
		HEAT TREATED		
Rounds, Squares, Hexagons, Octagons, Rectangles.	Up to 0.125 in............	55 000	30 000	..
	0.126 to 0.750 in..........	55 000	30 000	18
	0.751 to 3.000 in..........	53 000	30 000	18
	3.001 to 8.000 in..........	50 000	28 000	16
	Up to 0.750 in. thickness..	53 000	30 000	16
	0.751 to 3.000 in. thickness	50 000	28 000	16
Structural shapes	Standard sizes............	50 000	30 000	16

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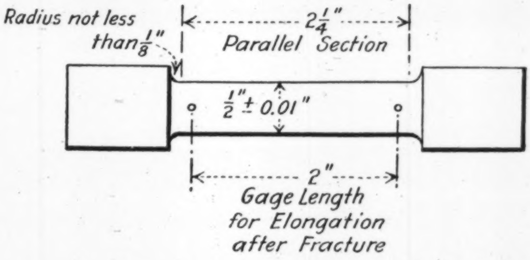
[a] The gage length for measurement of elongation shall be equal to four times the diameter or distance across flats except in sections for which a flat tension test specimen is used in which case the gage length shall be 2 in.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Test Specimen.

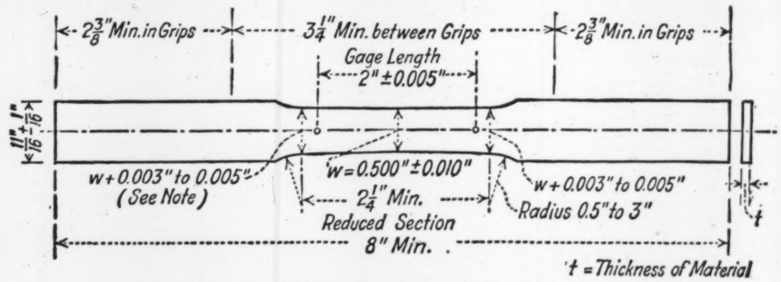
Bend Test. 5. Bend test specimens shall stand being bent through an angle of 180 deg. around a diameter equal to four times the thickness of the specimen without cracking.

Test Specimens. 6. (*a*) Test coupons shall be selected at random to represent each lot of 2000 lb. or fraction thereof, or such other quantity as may be mutually agreed upon between the manufacturer and purchaser.

(*b*) The tension test specimen may be a full section of the material, or the standard 0.505-in. tension test specimens, Fig. 1, machined from the test coupon may be used. In the case of thin material the specimen may have the form and dimensions of the standard sheet tension test specimen having a width of ½ in. and a reduced section of 2¼ in. as shown in Fig. 2.

(*c*) The bend test specimen may be (*1*) a full section of the material or (*2*) a $\frac{3}{4}$-in. round specimen machined from the material or (*3*) a rectangular specimen approximately 1 in. in width and having the thickness of the section from which it is taken, or a ratio of width to thickness not less than six to one. The edges of the rectangular specimen may be rounded to a radius of approximately one-half the thickness.

(*d*) For material up to $1\frac{1}{2}$ in. in diameter or thickness, the tension and bend test specimens shall be machined from the center of the section; for material $1\frac{1}{2}$ in. and over, specimens shall be machined from the material midway between the center and the outside of the section. Specimens shall be taken parallel to the direction of rolling or extrusion.



Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Standard Tension Test Specimen for Sheet Metals.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations. 7. Variations from the specified dimensions for the class of material ordered shall not exceed the amounts shown in Table II.

WORKMANSHIP AND FINISH

Workmanship and Finish. 8. The material shall be of uniform quality and temper, clean, sound, smooth, commercially straight or flat and free from pipes, laps, cracks, twists, seams, damaged ends and other injurious defects.

INSPECTION AND REJECTION

Inspection. 9. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 10. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY SHEET[1]

A.S.T.M. Designation: B 90 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope.

1. These specifications cover commercial magnesium-base alloy sheet having a specific gravity of 1.9 or less. Annealed sheet is the only temper covered by these specifications inasmuch as the metal should be in this form for subsequent forming operations (see Note 1). Two typical alloys are specified and are designated as Alloys Nos. 1 and 2 (see Note 2).

MANUFACTURE

Manufacture.

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

CHEMICAL COMPOSITION

Chemical Composition

3. The alloys shall conform to the following requirements as to chemical composition:

	ALLOY NO. 1	ALLOY NO. 2
Aluminum, per cent	3.5 to 6.5	....
Manganese, minimum, per cent	0.2	1.2
Copper, maximum, per cent	0.1	0.05
Other Impurities, maximum, per cent	0.3	0.2
Magnesium, per cent	remainder	remainder

Sampling.

4. (*a*) Samples for chemical analysis may be taken by sawing, shearing, or machining and shall represent the average cross-section of the sheet.

(*b*) The saw, cutter, or other tool shall be thoroughly cleaned. No lubricant shall be used in the sampling operation.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements. 5. (*a*) The sheet shall conform to the following requirements as to tensile properties:

	Alloy No. 1	Alloy No. 2
Tensile Strength, minimum, lb. per sq. in.	33 000	28 000
Elongation in 2 in., minimum, per cent	10	5

(*b*) The test specimens may be cut in any direction irrespective of the direction of rolling.

Number of Tests. 6. Two tension test specimens shall be cut from a random sheet representing each 500 lb. or fraction thereof of magnesium alloy, as mutually agreed upon between the manufacturer and purchaser.

WORKMANSHIP AND FINISH

Workmanship and Finish. 7. All sheets shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection. 8. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 9. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—The expression "annealed sheet" refers to metal that has been annealed or has been hot rolled under conditions that give no appreciable amount of strain-hardening.

NOTE 2.—Alloy No. 1 has a specific gravity of about 1.77. It is recommended where maximum physical properties are required. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 2 has a specific gravity of about 1.76. It is recommended where maximum corrosion resistance is required. The copper content should be kept as low as possible in order to minimize corrosion.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY WROUGHT SHAPES (OTHER THAN SHEET)[1]

A.S.T.M. Designation: B 91 - 32 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover fully-worked commercial magnesium-base alloy shapes, other than sheet, having a specific gravity of 1.9 or less (see Note 1). Mechanical working operations develop the maximum properties without the necessity of subsequent heat treatment. Two typical alloys are specified and are designated as Alloys Nos. 1 and 2 (see Note 2).

MANUFACTURE

Manufacture. 2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

CHEMICAL COMPOSITION

Chemical Composition. 3. The alloys shall conform to the following requirements as to chemical composition:

	ALLOY NO. 1	ALLOY NO. 2
Aluminum, per cent	3.5 to 8.5	....
Manganese, minimum, per cent	0.2	1.2
Copper, maximum, per cent	0.1	0.05
Other Impurities, maximum, per cent	0.3	0.2
Magnesium, per cent	remainder	remainder

Sampling. 4. (*a*) Samples for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter, or other tool shall be thoroughly cleaned. No lubricant shall be used in the sampling operation.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements. 5. The wrought sections shall conform to the following requirements as to tensile properties:

	ALLOY No. 1	ALLOY No. 2
Tensile Strength, minimum, lb. per sq. in.	35 000	30 000
Elongation in 2 in., minimum, per cent	8	4

Number of Tests. 6. Two tension specimens shall be cut from a random shape representing each 500 lb. or fraction thereof of magnesium alloy, as mutually agreed upon between the manufacturer and purchaser.

WORKMANSHIP AND FINISH

Workmanship and Finish. 7. All material shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection. 8. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 9. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—The expression "fully-worked" refers to metal that has been reduced 90 per cent or more in area during the mechanical deformation operations. Metal that has been given a smaller reduction in area will have properties intermediate between those of "as cast" and the "fully-worked" conditions.

NOTE 2.—Alloy No. 1 has a specific gravity of about 1.78. It is recommended where maximum physical properties are required. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 2 has a specific gravity of about 1.76. It is recommended where maximum corrosion resistance is required. The copper content should be kept as low as possible in order to minimize corrosion.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
MASONRY CEMENT[1]

A.S.T.M. Designation: C 91 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. These specifications cover cement to be used in conjunction with sand in the making of mortar for laying units of masonry construction above grade.

SPECIFICATIONS

PHYSICAL PROPERTIES

Fineness. 2. The residue on a standard No. 200 sieve shall not exceed 20 per cent by weight. Cement shall not be rejected for failure to meet the fineness test if, after drying at 100 to 110° C. for one hour and resieving, it meets this requirement.

Time of Setting. 3. Neat cement paste mixed to normal consistency shall not develop initial set in less than 60 minutes as determined by the Gillmore needle. Final set shall be attained within 48 hours.

Soundness. 4. Pats of neat cement, made and tested in accordance with Section 19, shall remain firm and hard and show no signs of distortion, checking, cracking, or disintegration under both conditions of storage. Mortar strength specimens at the time of test shall show no signs of distortion, checking, cracking, or disintegration.

Compressive Strength. 5. The average compressive strength of not less than three 2-in. cubes, made, stored and tested in accordance with Sections 20 to 25, shall be not less than 175 lb. per sq. in. at the age of 7 days. The average strength attained at 28 days shall be not less than that attained at 7 days.

PACKING AND MARKING

Packing and Marking. 6. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer and the net weight plainly marked thereon. All packages shall be in good condition at the time of inspection. Packages varying more than 5 per cent from the weight marked thereon may be rejected, and if the average weight of packages in any shipment as shown by weighing 50 packages taken at random is less than the weight marked thereon, the entire lot represented may be rejected.

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. G. A. Saeger, Secretary of Committee C-1 on Cement, 7417 Delmar Boulevard, St. Louis, Mo.

[2] **Accepted for publication as tentative by Committee E-10 on Standards, April 8, 1932.**

INSPECTION AND SAMPLING

Inspection. 7. Every facility shall be provided the purchaser for the necessary inspection and sampling.

Storage. 8. The cement shall be stored in a suitable weather-tight building which will protect it from dampness, and in such a manner as to permit safe and easy access for proper inspection and identification of each lot.

Number and Weight of Samples. 9. Each sample selected for purpose of tests shall weigh at least 5 lb. and shall represent not more than 200 bbl. If only one sample is taken it shall weigh at least 10 lb.

Shipment of Samples. 10. Samples shall be shipped and stored in air-tight, moisture-proof containers.

REJECTION

Rejection. 11. The cement shall be rejected if it fails to meet any of the requirements of these specifications. Cement remaining in storage prior to shipment for a period greater than six months after test shall be retested and shall be rejected if it fails to meet any of the requirements of these specifications.

METHODS OF TESTING

Methods of Testing. 12. All test procedures not otherwise specified shall be in accordance with the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1] The sieves shall conform to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[2]

Temperature. 13. The standard temperature shall be 70° F. (21° C.). The air of the laboratory, the materials, the mixing water, the moist closet and storage tanks shall be maintained as nearly as practicable at the standard temperature and shall not vary therefrom more than 5° F. (3° C.).

Preliminary Treatment of Samples. 14. The sample shall be given a preliminary sieving by being passed through a No. 20 sieve in order to thoroughly mix the sample, break up lumps and remove foreign materials.

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

FINENESS

15. Fineness shall be determined on a No. 200 sieve in accordance with Sections 13 to 18 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1] **Fineness.**

MIXING CEMENT PASTES AND MORTARS

16. Cement pastes and mortars shall be mixed in accordance with Sections 19 to 21 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials[1] except that the operation of mixing, squeezing and kneading with the hands shall be continued for 5 minutes. **Mixing.**

NORMAL CONSISTENCY

17. Normal consistency shall be determined by the Vicat apparatus in accordance with Sections 23 and 24 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1] **Consistency.**

TIME OF SETTING

18. Time of setting shall be determined by the Gillmore needle method in accordance with Sections 33 and 34 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1] The cement pats shall be stored during the test in a damp closet maintained at a relative humidity of 90 per cent or more. **Time of Setting.**

SOUNDNESS

19. Two pats of cement paste of normal consistency, as prepared for the time of setting tests, shall be made in accordance with Section 27 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1] After the first 24 hours in the damp closet maintained at a relative humidity of 90 per cent or more, one of the pats shall be stored in the air of the laboratory for 6 days and the other shall be immersed for 6 days in clean running water in storage tanks of non-corrodible material. Unsoundness is manifested by change in volume which causes distortion, cracking, checking or disintegration. Pats improperly made or exposed to drying may develop what are known as shrinkage cracks within the first 24 hours. The shrinkage cracks are not an indication of unsoundness. The failure of pats to remain **Soundness.**

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

on the glass, or the cracking of the glass to which the pats are attached, does not necessarily indicate unsoundness. Should the pat leave the plate, distortion may be detected with a straight edge applied to the surface which was in contact with the plate, provided the plate was flat before test.

COMPRESSIVE STRENGTH TESTS

Test Specimen.

20. The compression test specimen shall be a 2-in. cube. The molds shall be of non-corrodible metal and shall be so designed as to prevent spreading during molding. Molds shall be oiled with a mineral oil before using.

Standard Mortar.

21. (*a*) *Proportions.*—The mortar shall consist of one part cement to three parts of standard Ottawa sand, by weight. Ottawa sand shall conform to the requirements of Sections 36 to 38 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[1]

(*b*) *Preparation of Standard Mortar.*—The mortar shall be mixed in accordance with Section 16, with a measured quantity of water. The top of the flow table (see Paragraph (*c*)) shall be carefully wiped dry and the flow mold placed at the center and filled with the mortar. In filling the mold the mortar shall not be rammed, but gently puddled to insure uniform filling. The mortar shall be smoothed off level with the top of the mold by aid of a trowel and the mold then removed. Immediately, the table shall be dropped through a height of $\frac{1}{2}$ in., 25 times in 15 seconds. The flow is the resulting increase in diameter of the mortar mass, expressed as a percentage of the original diameter. The mortar shall be of standard consistency when the flow is 65 to 80. Trial mortars shall be made with varying percentages of water until the standard consistency is obtained. Each trial shall be made with fresh mortar. The quantity of water shall be expressed as a percentage of the weight of the combined dry materials.

(*c*) *Flow Table.*—The flow table apparatus shall consist of a rigid frame with a flat circular top, so mounted on a vertical shaft that it can be raised and dropped $\frac{1}{2}$ in. by means of a cam. The top shall be of non-corrodible metal, 10 in. in diameter, and with the attached shaft shall weigh 9 lb.

The mold shall be of non-corrodible material, 4 in. in inside diameter at the base, $2\frac{3}{4}$ in. in inside diameter at the top and 2 in. in height.

Molding of Test Cubes.

22. Immediately after mixing the standard mortar in accordance with Sections 16 and 21, the mortar shall be placed in the cube molds

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

which shall rest on plane non-absorbent plates. The molds shall be filled heaping full without compacting. Then the mortar shall be gently worked into the molds with the thumbs, using only sufficient effort to insure uniform filling of the molds. Additional mortar shall be heaped above the molds and smoothed off with a trowel. The molds and plates shall then be turned over upon plane non-absorbent plates oiled with mineral oil, the first plates removed, and the operation of heaping, thumbing and smoothing off repeated. No ramming or tamping shall be used, nor any trowelling in excess of that required to smooth off the specimen.

Storage of Test Cubes.

23. All test cubes, immediately after molding, shall be kept in the molds on plane plates in a damp closet, maintained at a relative humidity of 90 per cent or more, for 20 to 24 hours in such manner that the upper surfaces shall be exposed to moist air. The cubes shall then be removed from the molds and left freely exposed to the atmosphere in the damp closet until time of test.

Testing of Cubes.

24. The compressive strength test may be made with any type of verified compression testing machine of suitable capacity. Those faces of the cube which when molded were in contact with the sides of the molds shall be placed in contact with the surfaces through which the load is applied. A spherical-seated bearing block shall be used between the upper face of the cube and the head of the testing machine. The center of the sphere shall lie in that surface of the bearing block which is in contact with the cube, and the radius of the sphere shall be 1½ in. The cube shall be carefully centered in the testing machine and below the center of the bearing block. Cushioning materials shall not be used. The load shall be applied uniformly and without shock. The moving head of the testing machine shall travel at the rate of approximately 0.05 in. per minute when the machine is running idle. The specimens shall be tested immediately upon removal from the damp closet, or in case of delay they shall be kept covered with damp cloths in the interval between removal from the damp closet and time of test.

Calculation of Compressive Strength.

25. The total load indicated by the testing machine at failure of the test cube shall be recorded, and the unit compressive strength calculated in pounds per square inch of the cross-sectional area of the cube. Cubes that are manifestly faulty, or which give strengths differing by more than 15 per cent from the average value of all test cubes made from the same sample and tested at the same period, shall not be considered in determining the compressive strength.

TENTATIVE METHODS OF TESTING GYPSUM AND GYPSUM PRODUCTS[1]

A.S.T.M. Designation: C 26 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

FREE WATER IN GYPSUM

Free Water. 1. (*a*) Not less than 1 lb. of the entire sample as received shall be weighed, spread out in a thin layer in a suitable vessel, placed in a drying oven, and dried at 45° C. (113° F.) for 2 hours. It shall then be cooled in an atmosphere free from moisture, and weighed again. The loss of weight corresponds to the free water, and shall be calculated to percentage of sample as received.

(*b*) The dried sample shall be stored in an air-tight container until used.

FINENESS

Fineness. 2. Fineness shall be determined by sieving a known weight of the dried sample through sieves of the specified sizes and weighing the amount of material retained on each sieve. The material shall be shaken through the sieve with as little abrasion as possible.

The size of the sample to be used in determining fineness shall depend upon the particle size of the sample. If the sample will all pass a $\frac{1}{4}$-in. sieve, 100 g. will be sufficient; if the largest particles are more than 1 in. in diameter, at least 1000 g. shall be used. With these limitations the size of sample to be used is left to the discretion of the operator.

NOTE.—The sizes of the sieves to be used are given in the specifications of the American Society for Testing Materials covering the particular product in question.

CHEMICAL ANALYSIS OF GYPSUM AND CALCINED GYPSUM

Preparation of Sample. 3. A sample as prepared in Section 1 shall be reduced until it all passes a No. 60 (250-micron) sieve,[2] using extreme care not to expose unduly the material to moisture or to over-heating. The ground sample shall then be thoroughly re-mixed and stored in an air-tight container until used.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 211 W. Wacker Drive, Chicago, Ill.

These Tentative Methods are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Methods of Testing Gypsum and Gypsum Products (A.S.T.M. Designation: C 26 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 125.

[2] For detailed specifications for this sieve, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

Combined Water.

4. Place 1 g. of the sample in a covered crucible and dry at 215 to 230° C. (420 to 445° F.) to constant weight. Calculate the loss of weight to percentage of sample as received and report as combined water.

Carbon Dioxide.

5. Place the residue obtained after drying, as described in Section 4, in a suitable flask and dissolve it in dilute HCl (not stronger than 1:4) in such a way that the gas evolved, after being freed from H_2O vapor by calcium chloride or sulfuric acid, can be collected in either soda-lime or caustic potash and weighed. The solution should be boiled for 1 minute, and a current of CO_2-free air kept passing through the apparatus for 30 minutes. The increase of weight of the soda-lime or caustic potash corresponds to the weight of carbon dioxide, which shall be calculated to percentage of sample as received.

Silica and Insoluble.

6. Place 0.5 g. of the sample, prepared as described in Section 3, in a porcelain casserole. Add about 25 cc. of HCl (1:5), and evaporate to apparent dryness on a hot plate. Cool and add enough concentrated HCl to wet thoroughly. Add about 10 cc. of water, boil, filter, and wash. Put the filtrate back in the same casserole. Evaporate it to dryness and heat to about 120° C. (250° F.) for 1 hour and then cool. Add enough concentrated HCl to wet thoroughly. Add about 25 cc. of water, boil, filter, and wash. Transfer the two papers containing the two precipitates to the same crucible, ignite, and weigh. Calculate this weight to percentage of sample as received.

Iron and Alumina.

7. To the filtrate obtained as described in Section 6, add a few drops of HNO_3 and boil to insure oxidation of the iron. Add 2 g. of NH_4Cl previously dissolved in water. Make alkaline with NH_4OH. Digest hot for a few minutes until the precipitate coagulates. Filter, wash, ignite the precipitate and weigh as $Fe_2O_3 + Al_2O_3$. Calculate this weight to percentage of sample as received. This precipitate may be further treated to separate the two oxides, but this is generally unnecessary.

Lime.

8. (*a*) To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for $\frac{1}{2}$ hour, making sure that the solution is always alkaline with NH_4OH. Filter, wash, and ignite in a platinum crucible over a strong blast to constant weight. Calculate this weight to percentage of sample as received.

(*b*) *Alternative Method.*—To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for $\frac{1}{2}$ hour, making sure that the solution is always alkaline with

NH_4OH. Filter and wash. Transfer the precipitate to a beaker, and wash the filter paper with hot dilute H_2SO_4, catching the washings in the same beaker. Heat gently to complete solution, adding more H_2SO_4 if necessary. While still warm, titrate with a solution of $KMnO_4$ containing 5.6339 g. per liter, until the pink color is permanent. The number of cubic centimeters of $KMnO_4$ used gives directly the percentage of lime in the dried sample. Recalculate to percentage of sample as received.

Magnesia.

9. To the filtrate obtained as described in Section 8 (*a*) or (*b*), add enough water to give a total volume of about 600 cc. Cool. Add 10 cc. of NH_4OH and 5 g. $NaNH_4HPO_4$ dissolved in water. Stir until precipitate begins to form. Let stand over night. Filter, wash with a 2.5 per cent by weight solution of NH_4NO_3. Ignite and weigh. Multiply this weight by 0.36207 to find the weight of MgO. Then calculate to percentage of sample as received.

Sulfur Trioxide.

10. Dissolve 0.5 g. of the sample, prepared as described in Section 3, in 50 cc. of HCl (1:5). Boil. Add 100 cc. of boiling water, and continue boiling for 5 minutes. Filter immediately and wash thoroughly with hot water. Boil, and while boiling, add slowly 20 cc. of a boiling solution of $BaCl_2$ (10 per cent). Digest hot for 1 hour, or until precipitate settles. Filter and wash. Dry carefully. Ignite over Bunsen burner at lowest heat possible until filter paper is burned off. Ignite at bright red heat for 15 minutes, and weigh. Multiply this weight by 0.34297 to determine the weight of SO_3. Then calculate to percentage of sample as received.

Sodium Chloride.

11. Dissolve a 1-g. sample, prepared as described in Section 3, in boiling water, filter and wash with 250 cc. of boiling water. Add two or three drops of potassium chromate solution to the filtrate and titrate with an 0.05 *N* solution of silver nitrate. Each cubic centimeter of silver nitrate solution is equivalent to 0.002923 g. of sodium chloride. Calculate to percentage of sample as received.

Calculation of Results.

12. The results obtained by the methods given above shall be reported in the following form:

	PER CENT
Free water	
Combined water	
Carbon dioxide, CO_2	
Silica and insoluble, SiO_2	
Iron and alumina, R_2O_3	
Lime, CaO	
Magnesia, MgO	
Sulfur trioxide, SO_3	
Sodium chloride, NaCl	
Total	100.00±

EXPLANATORY NOTES

Since it is frequently advisable to recalculate these results, that they may be more enlightening, the following method is submitted for consideration:

(*a*) Multiply percentage of MgO by 2.0912 to find percentage of $MgCO_3$.

(*b*) Multiply the percentage of MgO by 1.0914 to find the percentage of CO_2 as $MgCO_3$.

(*c*) Deduct CO_2 as $MgCO_3$ from the CO_2 determined.

(*d*) Multiply the CO_2 remaining by 2.2742 to find percentage of $CaCO_3$.

(*e*) Add together the percentage of SiO_2, R_2O_3, $MgCO_3$, and $CaCO_3$, and report in the aggregate.

(*f*) Multiply the percentage of $CaCO_3$ by 0.56031 to find the percentage of CaO as $CaCO_3$.

(*g*) From the total percentage of CaO, deduct the percentage of CaO as $CaCO_3$. The remainder may be called "available CaO."

(*h*) The "available CaO" should bear to the SO_3 a ratio of 0.6991 to 1. Determine which (if either) is in excess.

(*i*) If the CaO is in excess, multiply the SO_3 by 0.6991, and subtract the result from the "available CaO." The remainder is reported as "excess CaO."

(*j*) If the SO_3 is in excess, multiply the "available CaO" by 1.4304 and subtract the result from the SO_3. The remainder is reported as "excess SO_3."

(*k*) Add together the "available CaO," and the SO_3, and subtract the "excess CaO" or "excess SO_3." The remainder is $CaSO_4$.

(*l*) If the $CaSO_4$ is present as $CaSO_4 \cdot \frac{1}{2}H_2O$, the percentage of $CaSO_4$ should bear to the percentage of combined water a ratio of 15.12 to 1. Determine which (if either) is in excess.

(*m*) If the $CaSO_4$ is in excess some of it is present in the anhydrous form. Multiply the percentage of combined water by 15.12 to find the percentage of $CaSO_4$ as $CaSO_4 \cdot \frac{1}{2}H_2O$. The difference between the total $CaSO_4$ and the percentage of $CaSO_4$ as $CaSO_4 \cdot \frac{1}{2}H_2O$, is the $CaSO_4$ in the anhydrous form.

(*n*) If the water is in excess, some of the $CaSO_4$ is present as gypsum. Let x = percentage of $CaSO_4 \cdot \frac{1}{2}H_2O$, and y = percentage of $CaSO_4 \cdot 2H_2O$. Then: $x + y$ = percentage of $CaSO_4$ (as found in *k*) + percentage of water.

$0.06206\,x + 0.2093y$ = percentage of combined water.

Solve these equations for x and y. Report x as percentage of "calcined gypsum," $CaSO_4 \cdot \frac{1}{2}H_2O$. Report y as percentage of gypsum, $CaSO_4 \cdot 2H_2O$.

Having made these calculations, the results may be reported as follows:

	PER CENT
Gypsum, $CaSO_4 \cdot 2H_2O$	
Calcined gypsum, $CaSO_4 \cdot \frac{1}{2}H_2O$	
Anhydrite, $CaSO_4$	
Excess CaO or Excess SO_3	
Sodium chloride, NaCl	
Other ingredients	
Total	100.00 ±

The presence of the different forms of $CaSO_4$ may be corroborated by a microscopic examination.

PRECAUTIONS FOR PHYSICAL TESTS

Precautions for Physical Tests. 13. Gypsum products are peculiar in that their properties are very greatly affected by the small amounts of impurities which may be introduced by careless laboratory manipulation. In order to obtain concordant results, it is therefore, absolutely essential to observe the following precautions:

(*a*) All apparatus shall be kept thoroughly clean. Especially shall all traces of set plaster be removed.

(*b*) Distilled water, free from chlorides and sulfates, shall be used exclusively.

(*c*) Standard Ottawa sand shall be used exclusively. This shall be prepared for use by washing it once with HCl (1:4) and four times with distilled water, and then drying it.

TESTING CONSISTENCY OF GYPSUM PLASTER

Testing Consistency. 14. An accurate method for determining consistency is the most important step in the standardizing of physical methods for testing cementitious materials.

(*a*) *Testing Consistency of Calcined Gypsum.*—Calcined gypsum shall be considered of testing consistency when a penetration of 30 mm. ± 2 mm. is obtained when tested in accordance with Section 16, weight of rod and plunger for this determination to be 50 g. Testing consistency shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the gypsum.

(*b*) *Testing Consistency of Gypsum Mixtures.*—Sanded gypsum mixtures and gypsum wood-fiber plaster shall be considered of testing consistency when a penetration of 20 mm. ± 3 mm. is obtained when tested in accordance with Section 16, weight of rod and plunger for these determinations to be 150 g. Testing consistency shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the mixture.

Apparatus. 15. (*a*) *Modified Vicat Apparatus.*—The modified Vicat apparatus (Fig. 1) consists of a bracket, *A*, bearing a movable brass rod, *B*, 6.3 mm. in diameter and of suitable length to fit the Vicat bracket. On the lower end of the rod is attached a plunger, *C*, 19.0 mm. in diameter, and 44.4 mm. in length, made of aluminum tubing. The total weight of the rod with plunger is 50 g. This total weight may be increased by means of a weight, *D*, screwed into the rod. The rod can be held in any position by means of a screw, *E*, and has a mark midway between the ends which moves under a scale, *F*, graduated in millimeters, attached to the bracket, *A*.

(*b*) *Mold.*—The conical ring mold shall be made of a non-corroding, non-absorbent material, and shall have an inside diameter of 7 cm. at the base, 6 cm. at the top and a height of 4 cm.

(*c*) *Base Plate.*—The base plate for supporting the ring mold shall be of plate glass and about 10 cm. square.

Method.

16. (*a*) *Preparation of Apparatus.*—Clean the plunger, mold and base plate of the modified Vicat apparatus. Apply a thin coat of vaseline or other suitable lubricant to the upper surface of the base plate in order to prevent leaks during the test.

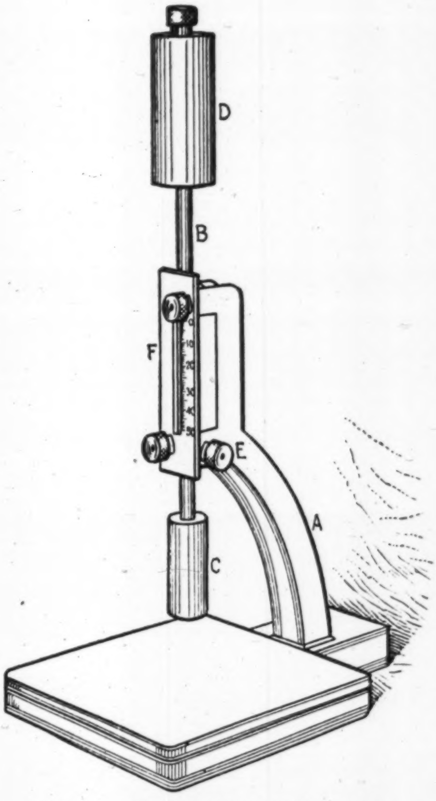

FIG. 1.—Modified Vicat Apparatus.

(*b*) *Procedure.*—To a known volume of water, add approximately 0.2 g. of commercial retarder, weigh out 200 g. of the sample and sift it into the water, allowing it to soak for 2 minutes. Then stir for 1 minute to an even fluidity. Pour this mixture into the ring mold, work slightly to remove air bubbles and strike off flush with the top of the mold. Wet the plunger and then lower it to the surface of the mix, approximately at the center of the mold. Read the scale and release the plunger immediately. After the rod has settled read the scale again.

Readings are reproducible on a retarded mix and therefore in order to eliminate error two or three determinations should be made on each mix, care being taken to have the mold completely filled and the plunger clean and wet.

WATER-CARRYING CAPACITY

Water-Carrying Capacity.

17. The water-carrying capacity is the amount of water, calculated as percentage by weight of the dry material, which is necessary to bring the mixture to testing consistency.

DRY BULK

Dry Bulk.

18. Dry bulk is the volume in cubic centimeters occupied by 100 g. of dry material.[1] Place a No. 10 (2000-micron) sieve[1] above a No. 20 (840-micron) sieve[2] and hold the two sieves at a height of 12 in. (30 cm.) above a perpendicular-sided receptacle of known volume (about 400 cc.). Place the material under test on top of the No. 10 sieve and pass it through the No. 10 and No. 20 sieves, filling the receptacle. Then strike off flush with the top of the receptacle, and obtain the net weight of the contents in grams. Obtain the average of three tests according to this method and express the average result in cubic centimeters per 100 g.

WET BULK

Wet Bulk.

19. Wet bulk is the volume in cubic centimeters occupied by a mixture of 100 g. of dry material mixed with water to testing consistency.

TIME OF SETTING

Time of Setting.

20. Mix 200 g. of the sample (Note) with enough water to make a paste of testing consistency as described in Sections 14 to 16.

NOTE.—When the sample to be tested is a sanded mixture, use 300 g. and mix to testing consistency for sanded mixture.

Fill a mold with the paste, and test for time of set with a Vicat needle. The specifications for the mold and needle are given in Sections 23 and 32 of the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77) of the American Society for Testing Materials.[3]

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[1] Dry Bulk is expressed as the volume in cubic centimeters occupied by 100 g. of dry materia instead of "grams per 100 cc.," since Bulk is understood to mean Volume per Unit Weight rather than Weight per Unit Volume.

[2] For detailed specifications for this sieve, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1930 Book of A.S.T.M. Standards, Part II, 1119.

[3] 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

When conducting the test, the needle is allowed to sink into the paste at frequent intervals. After each penetration, the needle must be wiped clean, and the paste moved slightly so that the needle will not strike the same hole twice.

The frequency of the penetrations will depend upon the character of the material. If the sample is not retarded, it should be tested every two minutes until nearly set, and then every minute. If the sample is retarded, the intervals at first may be as long as one hour, but in any case they shall be so selected that the time of set is ascertained to the nearest minute.

Set is considered complete when the needle no longer penetrates to the bottom of the paste. The minutes elapsed, from the time when the sample was first added to the water, to the time when set is complete, are recorded as the time of set of the sample.

> *Caution:* For test to determine the time of set, it is absolutely essential that all dishes and utensils be clean. Especially must they be free from all traces of set gypsum. Use distilled water.

TENSILE STRENGTH

Test Specimen.

21. The form of test specimen shown in Fig. 2 shall be used.[1] The molds shall be made of non-corroding metal and have sufficient material in the sides to prevent spreading during molding. Molds shall be oiled with a mineral oil. The dimensions of the briquet molds shall conform to the following requirements: width of mold, between inside faces, at waist line of briquet, 1 in. with tolerances of ± 0.01 in. for old molds and ± 0.005 in. for new molds; thickness of new mold, measured at point of greatest thickness on either side of mold at waist line, 1 in. with tolerances of + 0.004 in. and − 0.002 in.

Tensile Strength.

22. Mix 500 g. of the sample (Note) to testing consistency as described in Sections 14 to 16. Cast into a five-gang briquet mold of the shape and size shown in Fig. 2.[1] Do not cast each briquet successively, but move the containing vessel back and forth over the molds while pouring continuously. Work the briquet slightly with the point of the trowel to remove air bubbles, and level off the briquets flush with top of mold. Retain briquets, not less than 24 hours, in the molds in moist air until thoroughly hardened. Remove from molds and dry the specimens at a temperature of not less than 21.1° C. (70° F.) nor more than 37.8° C. (100° F.) in an atmosphere of not more than 50 per cent relative humidity. The specimens shall be

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[1] This test specimen is identical with the briquet specimen used in the tensile strength test for cement described in the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77), see 1932 Supplement to Book of A.S.T.M. Standards, p. 23.

weighed at 1-day intervals until the weight has become constant to within 0.1 per cent. The specimens shall then be tested in a standard testing machine suitable for the determination of tensile strength.

NOTE.—When the material to be tested is a sanded mixture, use not less than 750 g. and mix to testing consistency for sanded mixture.

Report. 23. The average tensile strength shall be reported as the tensile strength of the material, except that if one or two of the briquets vary more than 15 per cent from the average of the five, they shall be discarded and the tensile strength shall be reported as the average of the remaining specimens. In case three or more briquets vary more than 15 per cent from the average, the results shall be discarded and the test repeated.

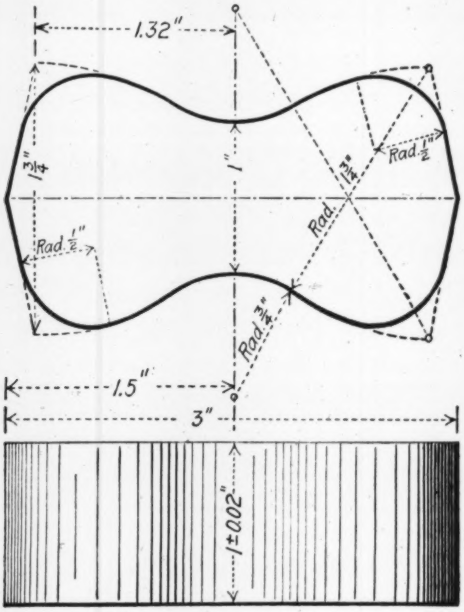

FIG. 2.—Details for Briquet.

COMPRESSIVE STRENGTH

Compressive Strength. 24. Mix 1500 g. of the sample to testing consistency as described in Sections 14 to 16. Cast into five 2-in. split cubes set plumb upon metal or glass plates. Do not cast each cube successively, but move the containing vessel back and forth over the cubes while pouring continuously. Work the cubes slightly with the point of the trowel to remove air bubbles, and level off flush with the top of cubes. Retain cubes, not less than 24 hours, in the molds in moist air until thoroughly hardened. Remove from molds and dry the specimens at a temperature of not less than 21.1° C. (70° F.) nor more than 37.8° C. (100° F.) in an atmosphere of not more than 50 per cent relative humidity. The specimens shall be weighed at 1-day intervals until the weight has become constant to within 0.1 per cent. The specimens shall then be tested in a standard testing machine suitable for the determination of compressive strength.

Report.

25. The average compressive strength shall be reported as the compressive strength of the material, except that if one or two of the cubes vary more than 15 per cent from the average of the five, they shall be discarded and the compressive strength shall be reported as the average of the remaining specimens. In case three or more cubes vary more than 15 per cent from the average, the results shall be discarded and the test repeated.

COMPRESSIVE STRENGTH OF GYPSUM PARTITION TILE OR BLOCK

Compressive Strength of Tile or Block.

26. (*a*) Not less than ten full-size gypsum tile specimens shall be used.

(*b*) The test specimens shall be dried at a temperature of not less than 21.1° C. (70° F.) nor more than 37.8° C. (100° F.) in an atmosphere of not more than 50 per cent relative humidity. The specimens shall be weighed at 1-day intervals until constant weight is attained. At the option of the manufacturer or purchaser, strength tests may be conducted on samples that are dried at room temperature. However, in cases of controversy all test samples shall be dried to constant weight as herein prescribed.

(*c*) The tile or block shall be tested in the position in which it is designed to be used, and shall be bedded on and capped with a felt pad not less than $\frac{1}{8}$ in. nor more than $\frac{1}{4}$ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test specimens may be suitably capped with calcined gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When calcined gypsum is used for capping, the test may be conducted after the capping has set, and the specimen tile dried to constant weight in accordance with Paragraph (*b*).

(*d*) The loading head shall completely cover the bearing area of the tile, and the applied load shall be transmitted through a spherical bearing block of proper design. The speed of the moving head of the testing machine shall be not more than 0.05 in. per minute.

ABSORPTION OF GYPSUM PARTITION TILE OR BLOCK

Absorption of Tile or Block.

27. (*a*) The absorption shall be determined upon a test specimen of partition tile or block consisting of approximately one-half of a full-size tile.

(*b*) The test specimen shall be dried to constant weight as prescribed for the determination of the compressive strength in accordance with Section 26 (*b*).

(*c*) The dried test specimen shall be submerged in water until a constant saturated weight is attained, but in no event for a period of less than two hours, the water temperature being maintained at between 21 and 27° C. (70 and 80° F.). The test specimen shall be removed, the surface wiped off with a damp cloth and the specimen weighed immediately. The percentage of absorption shall be calculated on the dry weight from the formula:

$$\text{Percentage of absorption} = \frac{100\,(B - A)}{A}$$

where A = weight of dry test specimen; and
B = weight of saturated test specimen.

(*d*) The rate of absorption shall be determined by sealing upon the face of the test specimen, which shall first be dried to constant weight as prescribed for determination of the compressive strength, in accordance with Section 26 (*b*), a glass tube $1\frac{1}{2}$-in. internal diameter and 12 in. in length, graduated in centimeters and located centrally over a core. Into this tube shall be poured 250 cc. of water at a temperature of between 21 and 27° C. (70 and 80° F.). The rate of absorption shall be reported in cubic centimeters per minute.

FLEXURAL STRENGTH OF GYPSUM BOARDS

Flexural Strength of Gypsum Boards.

28. (*a*) *Test Specimens.*—The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 15.6 to 29.4° C. (60 to 85° F.) in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*). *Procedure.*—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen and shall be rounded to a radius of $\frac{1}{8}$ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

(*c*) *Report.*—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

TENTATIVE METHOD OF TEST
FOR
STRUCTURAL STRENGTH OF FINE AGGREGATE USING CONSTANT WATER-CEMENT-RATIO MORTAR[1]

A.S.T.M. Designation: C 87 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. This test is intended for determining the "structural strength" of sands to be used as fine aggregate in concrete by means of a compression test on a mortar of plastic consistency and gaged to a definite water-cement ratio.

Mortar. 2. Cement and water in quantities[2] which will give a water-cement ratio of 0.6 by weight shall be placed in an appropriate vessel[3] and the cement permitted to absorb water for 1 minute. The materials shall then be mixed with a spoon[3] into a smooth paste. Saturated and surface-dried sand from a sample of known weight[2] shall be beaten into the mixture until the material appears to be of the desired consistency (flow 100 ± 5). The mixing shall be continued for 30 seconds, and a determination of the flow made.

Flow Test. 3. The consistency shall be measured by use of the 10-in. flow table consisting of a circular bronze plate 10 in. in diameter, so mounted that the surface is level, and equipped with a mechanism for raising the plate ⅛ in. and allowing it to fall without cushioning. A right truncated cone, 2¾ in. in diameter at the top, 4 in. in diameter at the bottom, and 2 in. in height, shall be used to measure the volume of the mortar for the test. Immediately after mixing, the mortar shall be placed in the cone which has been carefully centered on the flow table. The mortar shall be rodded 25 times with a ⅜-in. rod, the surplus struck off, the plate wiped clean, the cone removed, and the table given 30 drops in 30 seconds. The percentage of increase in the diameter of the base of the pat, measured on two diameters at right angles to each other, shall be known as the flow.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

[2] For six 2-in. cubes, 600 g. of cement and 359 cc. of water will usually give sufficient mortar. The quantity of sand used with this amount of cement may vary from 1200 g. for fine sand to 2000 g. or more for coarse sand.

[3] The vessel used is an ordinary sauce pan of 4 qt. capacity, 9½ in. in diameter at the top and 4½ in. high. The spoon is a large iron kitchen spoon.

4. Should the flow be too great, the mortar may be returned to the mixing vessel, additional sand added, and another determination of the flow made. If the mortar is too dry, the batch shall be discarded. The quantity of sand used shall be determined by subtracting the weight of the portion remaining after mixing from the weight of the initial sample.

Molding Compression Specimens. 5. Immediately following the determination of the flow, the mortar shall be placed in 2 by 4-in. cylindrical molds in three layers, or 2-in. cubes in two layers, each layer rodded in place with 25 strokes of a $\frac{3}{8}$-in. rod, and the mold filled to overflowing. The specimens shall be placed in a moist closet for curing. Three to four hours after molding the specimens shall be struck off to a smooth surface. Twenty to twenty-four hours after molding, the specimens shall be removed from the molds and stored in water until tested.

Temperature. 6. The temperature of the mixing water, moist closet, and storage tank shall be maintained between 65 and 75° F.

Capping. 7. If the specimens are cylindrical, they shall be carefully capped with plaster of Paris before testing. Cubes made in suitable molds need not be capped and shall be tested at right angles to the direction of molding.

TENTATIVE METHOD OF TEST

FOR

SOUNDNESS OF FINE AGGREGATES BY USE OF SODIUM SULFATE[1]

A.S.T.M. Designation: C 88 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope. 1. This method of test is intended for testing fine aggregates to determine their resistance to a solution of sodium sulfate.

NOTE.—The results obtained with this test method shall be considered only as a guide in the selection of aggregates. It is not intended that the test shall be used as an arbitrary basis for rejection of the material without taking other factors into account; consideration should be given to the results obtained with the material when exposed to actual weathering conditions.

APPARATUS

Containers. 2. Suitable containers for immersing the samples of aggregate in the solution in accordance with the procedure hereinafter described shall be selected. The containers should be non-metallic or of metal not subject to corrosion by sodium sulfate.

NOTE—No standard form of container is recommended since different practices will be most convenient in various laboratories and the committee does not feel that this question, except for obvious fundamentals, is of importance. Two general methods of immersion have been used as follows:

(*1*) Each sample placed in a water-tight container and covered with the sodium-sulfate solution.

(*2*) Each sample placed in a container with a wire mesh bottom and immersed in a vat containing the sodium sulfate solution. Care should be taken to prevent loss by floatation if uncovered containers are submerged. If nesting sieves are used precaution should be taken to prevent loss of material from one sieve to another.

Temperature Regulation. 3. Suitable means for regulating the temperature of the sodium sulfate solution during the immersion of the samples shall be provided.

Weighing Equipment. 4. A balance having a capacity not less than 500 g., sensitive to at least 0.1 g., shall be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

Drying Oven. 5. The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 105 to 110° C. (221 to 230° F.).

Sodium Sulfate Solution. 6. The sodium sulfate solution shall be saturated by dissolving the salt, either of the anhydrous (Na_2SO_4) or crystalline ($Na_2SO_4 \cdot 10\ H_2O$) form, in water at a temperature of 24 to 27° C. (75 to 80° F.). The solution shall be thoroughly stirred during the addition of the salt and sufficient excess salt shall be added to insure saturation. About 500 g. of the anhydrous form or 1000 g. of the decahydrate will be required for each liter of water. The solution shall be allowed to cool before use to a temperature of 21° C. ± 1° C. (70° F. ± 2° F.).

TEST SAMPLE

Sample of Fine Aggregate. 7. Fine aggregate for the test shall be passed through a ⅜-in. sieve. The sample shall be of such size that it will yield not less than 100 g. of each of the following sizes present in amounts of 5 per cent or more, expressed in terms of sieves conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials:[1]

Retained on Sieve No. 100, passing Sieve No. 50
" " " " 50, " " " 30
" " " " 30, " " " 16
" " " " 16, " " " 8
" " " " 8, " " " 4
" " " " 4, " ⅜-in. Sieve

Should the fine aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium-sulfate treatment as the average of the sizes tested.

Preparation of Test Sample. 8. The sample shall be thoroughly washed on a No. 100 sieve and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), and separated into the different sizes by sieving as follows:

Make a rough separation of the graded sample by means of a nest of the standard sieves specified in Section 7. From the fractions obtained in this manner select samples of sufficient size to yield 100 g. after sieving to refusal. In general, a 110-g. sample will be sufficient. Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the samples. Samples consisting of 100 g. shall be weighed out of each of the separated fractions after final sieving and placed in separate containers for the test.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

PROCEDURE

Storage of Samples in Solution.

9. The samples shall be immersed in the prepared solution of sodium sulfate in such a manner that the solution covers them to a depth of at least ½ in. The containers should be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The immersed samples shall be maintained at a temperature of 21° C. ± 1° C. (70° F. ± 2° F.) for a period of 18 hours.

NOTE.—A moist room such as is used for curing concrete and mortar test specimens offers a convenient means of controlling the storage temperature. The presence of a few crystals of sodium sulfate in the container is essential to keeping the solution saturated.

Drying Samples After Immersion.

10. After the 18-hour immersion period the aggregate samples shall be removed from the solution and placed in the drying oven. The oven shall have been brought previously to a temperature of 105 to 110° C. (221 to 230° F.). Care shall be exercised to avoid loss of any of the aggregate particles or detritus coarser than a No. 100 sieve. The samples shall be dried to constant weight at the specified temperature. After drying, the samples shall be allowed to cool to within the range of the temperature permissible for the solution in which they are to be immersed, when they shall again be immersed in the prepared solution as described in Section 9.

Cycles.

11. The process of alternate immersion and drying shall be repeated until the required number of cycles is obtained. Unless otherwise specified, five cycles shall constitute a test.

Examination.

12. The examination of the test sample shall be made as follows:

(*a*) After the completion of the final cycle and after the sample has cooled, the sample shall be washed free from sodium sulfate as determined by the reaction of the wash water with barium chloride ($BaCl_2$).

NOTE.—The operator should assure himself that this procedure washes the sample free of sodium sulfate by testing the wash water from each sample. Barium chloride ($BaCl_2$) solution will cause a precipitate if sodium sulfate is present

(*b*) After the sodium sulfate has been removed, each fraction of the sample shall be dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), weighed and screened over the same sieve on which it was retained before the test. The particles retained on the sieve shall be weighed and the weight recorded.

NOTE.—In addition to the procedure described in Paragraphs (*a*) and (*b*) the following is suggested as giving additional information of value:

Each fraction should be examined visually in order to determine if there is any evidence or excessive splitting of the sand grains.

After treating each separate fraction of sample as described in Paragraph (*b*), all sizes, including the detritus, shall be combined and a sieve analysis made using as many of the following sieves as are required: Nos. 100, 50, 30, 16, 8, 4. The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

REPORT

Report. 13. The report shall include the following:

(*a*) Weight of each fraction of sample before test.

(*b*) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction.

(*c*) Weighted average calculated from the percentages of loss for each fraction and based on the grading of the sample as received for examination.

Report Form. 14. Table I, shown with test values inserted for purpose of illustration, is a suggested form for recording test data.

TABLE I.—FORM FOR RECORDING TEST DATA ON SODIUM SULFATE SOUNDNESS TEST OF FINE AGGREGATES. (Test values shown are for purpose of illustration.)

Sieve Size		Grading of Original Sample, per cent	(a) Weight of Test Fractions Before Test, g.	(b) Percentage Passing Finer Sieve After Test (Actual per cent Loss)	(c) Weighted Average (Corrected per cent Loss)
Passing	Retained on				
No. 100		5.0	....	0[a]	0
No. 50	No. 100	6.4	100	3.5	0.22
No. 30	No. 50	26.0	100	4.2	1.09
No. 16	No. 30	25.2	100	4.8	1.21
No. 8	No. 16	17.0	100	8.0	1.36
No. 4	No. 8	10.8	100	11.2	1.21
$\frac{3}{8}$ in.	No. 4	9.6	100	7.1	0.68
Totals		100.0	600		5.77

[a] Not tested; assumed to be zero.

TENTATIVE METHOD OF TEST

FOR

SOUNDNESS OF COARSE AGGREGATES BY USE OF SODIUM SULFATE[1]

A.S.T.M. Designation: C 89 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Scope.

1. This method of test is intended for testing coarse aggregates to determine their resistance to a solution of sodium sulfate.

NOTE—The results obtained with this test method shall be considered only as a guide in the selection of aggregates. It is not intended that the test shall be used as an arbitrary basis for rejection of the material without taking other factors into account; consideration should be given to the results obtained with the material when exposed to actual weathering conditions.

APPARATUS

Containers.

2. Suitable containers for immersing the samples of aggregate in the solution in accordance with the procedure hereinafter described shall be selected. The containers should be non-metallic or of metal not subject to corrosion by sodium sulfate.

NOTE.—No standard form of container is recommended since different practices will be most convenient in various laboratories, and the committee does not feel that this question, except for obvious fundamentals, is of importance. Two general methods of immersion have been used as follows:

(*1*) Each sample placed in a water-tight container and covered with sodium-sulfate solution.

(*2*) Each sample placed in a perforated container and immersed in a vat containing the sodium sulfate solution.

Temperature Regulation.

3. Suitable means for regulating the temperature of the sodium sulfate solution during the immersion of the samples shall be provided.

Weighing Equipment.

4. A balance having a capacity not less than 5000 g., sensitive to at least 1 g., shall be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

Drying Oven.

5. The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 105 to 110° C. (221 to 230° F.).

Sodium Sulfate Solution.

6. The sodium sulfate solution shall be saturated by dissolving the salt, either of the anhydrous (Na_2SO_4) or crystalline ($Na_2SO_4 . 10H_2O$) form, in water at a temperature of 24 to 27° C. (75 to 80° F.). The solution shall be thoroughly stirred during the addition of the salt and sufficient excess salt shall be added to insure saturation. About 500 g. of the anhydrous form or 1000 g. of the decahydrate will be required for each liter of water. The solution shall be allowed to cool before use to a temperature of 21° C. ± 1° C. (70° F. ± 2° F.).

TEST SAMPLE

Samples of Coarse Aggregate.

7. The coarse aggregate for the test shall consist of material from which the sizes finer than the No. 4 sieve have been removed. The sample shall be of such a size that it will yield not less than the following amounts of the different sizes present in amounts of 5 per cent or more:

No. 4 to ⅜-in. size (square openings)	100 g.
⅜ to ¾-in. size " "	300 g.
¾ to 1½-in. size " "	1500 g.
1½ to 2½-in. size " "	3000 g.
Larger sizes by 1-in. spread in sieve size	3000 g.

Should the sample of coarse aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium sulfate treatment as the average of the sizes tested.

Preparation of Test Sample.

8. For making the sodium sulfate test on ledge rock, the sample shall be prepared by breaking it into fragments such that the weights of the fractions specified in Section 7 smaller than 2½ in. may be procured. The mechanical analysis of the entire sample of broken fragments shall be obtained after first sieving the sample through the 2½-in. sieve and rejecting the material passing the No. 4 sieve. The test shall then be made as described in Sections 9 to 14, using the mechanical analysis of the broken fragments for the purpose of weighting the percentages of loss of the several fractions.

The sample shall be thoroughly washed and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), and separated into the different sizes by screening to refusal. The proper weight of sample for each fraction shall be weighed out and placed in separate containers for the test. In the case of fractions coarser than the ¾-in. sieve, the number of particles shall be counted.

PROCEDURE

Storage of Sample in Solution.

9. The samples shall be immersed in the prepared solution of sodium sulfate in such a manner that the solution covers them to a depth of at least ½ in. The containers should be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The immersed samples shall be maintained at a temperature of 21° C. ± 1° C. (70° F. ± 2° F.) for a period of 18 hours.

NOTE.—A moist room such as is used for curing concrete and mortar test specimens offers a convenient means of controlling the storage temperature. The presence of a few crystals of sodium sulfate in the containers is essential to keeping the solution saturated.

Drying Samples After Immersion.

10. After the 18-hour immersion period the aggregate samples shall be removed from the solution and placed in the drying oven. The oven shall have been brought previously to a temperature of 105 to 110° C. (221 to 230° F.). Care shall be exercised to avoid loss of any aggregate particles.[1] The samples shall be dried to constant weight at the specified temperature. After drying, the samples shall be allowed to cool to within the range of temperature permissible for the solution in which they are to be immersed, when they shall again be immersed in the prepared solution as described in Section 9.

Cycles.

11. The process of alternate immersion and drying shall be repeated until the required number of cycles is obtained. Unless otherwise specified, five cycles shall constitute a test.

Examination.

12. Fractions of samples coarser than ¾ in. shall be examined qualitatively after each immersion and quantitatively at the completion of the test. Fractions finer than ¾ in. shall be examined quantitatively only, and after the completion of the test.

Qualitative Examination.

13. The qualitative examination and record shall consist of: (*1*) observing the effect of action by the sodium sulfate solution and the nature of the action, and (*2*) counting the number of particles affected.

NOTE.—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking.

Quantitative Examination.

14. The quantitative examination shall be made as follows:

(*a*) After the completion of the final cycle and after the sample has cooled, the sample shall be washed free from sodium sulfate as determined by the reaction of the wash water with barium chloride ($BaCl_2$).

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[1] The detritus also should be saved if the complete analysis suggested in the Note in Section 14 (*b*) is made.

NOTE.—The operator should assure himself that this procedure washes the sample free of sodium sulfate by testing the wash water from each sample. Barium chloride ($BaCl_4$) solution will cause a precipitate if sodium sulfate is present.

(*b*) After the sodium sulfate has been removed, each fraction of the sample shall be dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), weighed and screened over the same sieve on which it was retained before the test. The weight of the material passing the sieve shall be determined and the weight recorded.

NOTE.—While only particles larger than the ¾-in. size are to be examined qualitatively it is recommended that examination of the smaller sizes be made in order to determine if there is any evidence of excessive splitting.

In addition to the procedure described in Paragraphs (*a*) and (*b*) the following is suggested as giving addional information of value: After treating each separate fraction of sample as described in Paragraph (*b*) all sizes, including the detritus, shall be combined and a sieve analysis made using a complete set of sieves for the determination of the fineness modulus. The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

REPORT

Report. 15. The report shall include the following:

(*a*) Weight of each fraction of sample before test;

(*b*) Number of particles in each fraction of sample coarser than ¾ in. before test;

(*c*) Number of pieces affected, in fractions coarser than ¾ in. only, classified as to number disintegrated, split, cracked, flaked, etc.;

(*d*) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction.

(*e*) Weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test.

Report Form. 16. Table I, shown with test values inserted for purpose of illustration, is a suggested form for recording test data.

TABLE I.—FORM FOR RECORDING TEST DATA ON SODIUM SULFATE SOUNDNESS TEST OF COARSE AGGREGATES. (Test values shown are for purpose of illustration.)

Sieve Size		Grading of Original Sample, per cent	(a) Weight of Test Fractions Before Test, g.	(b) Percentage Passing Finer Sieve After Test (Actual per cent Loss)	(c) Weighted Average (Corrected per cent Loss)
Passing	Retained on				
2½ in.	1½ in.	20.0	3000[a]	4.8	0.96
1½ in.	¾ in.	45.0	1500[a]	8.0	3.60
¾ in.	⅜ in.	23.0	300[a]	9.6	2.20
⅜ in.	No. 4	12.0	100[a]	11.2	1.34
Totals		100.0	4900		8.10

[a] Minimum amounts; larger samples may be used.

TENTATIVE METHOD OF TEST
FOR
PARTICLE SIZE OF GROUND REFRACTORY MATERIALS[1]

A.S.T.M. Designation: C 92 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. This method of test is intended for determining particle size of ground refractory raw materials and finished products, such as fire-clay mortars and high-temperature cements. The test data are of use in helping to maintain uniformity in manufacturing process, in development work, and in the purchase or sale of certain finished products. The materials or aggregates to which water is added for their use, or those which are shipped in plastic condition, are to be subjected to the wet method of sieve analysis. This group includes plastic clays, mixes containing plastic clays, fire-clay mortars, and high-temperature cements.

SAMPLING

Samples. 2. Samples received for purpose of tests shall consist of at least 500 g. and shall be representative of the material under test.

PROCEDURE FOR DRY SIEVE ANALYSIS

Treatment of Sample. 3. The sample shall be heated to 120° C. and held at that temperature for 2 hours. After cooling, 100 g. shall be weighed to the nearest 0.1 g.

Procedure. 4. (*a*) *Machine Sieving.*—When the sieving is to be done by machine, sieves to be used for the sieve analysis shall be arranged in order so as to have the coarsest sieve at the top of the nest. After transferring the 100-g. sample to the top sieve, the nest shall be placed in a suitable sieving machine. The machine shall be operated for about 15 minutes or until less than 0.1 g. of the material passes through each sieve after 1 minute of sieving. The sieves shall then be carefully separated and the amount of material retained on each sieve shall be determined by weighing to the nearest 0.1 g.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

(*b*) *Hand Sieving.*—When the sieving is to be done by hand, the sieves shall be handled in groups of two, and shall be conducted by holding them in a slightly inclined position, at the same time rotating and tapping the sieves. Sieving shall be continued until less than 0.1 g. of the material passes through each sieve after 1 minute of sieving.

Report. 5. Results of all sieve analyses shall be reported on the dry basis as the percentage passing the various sieves, and the calculations shall be reported to the nearest 0.1 per cent.

PROCEDURE FOR WET SIEVE ANALYSIS

Treatment of Sample. 6. (*a*) *Dry Material.*—If the material is received in the dry condition, the sample shall be dried and weighed in accordance with Section 3.

(*b*) *Wet Material.*—If the sample as received contains more than 5 per cent of water (plastic mixes, plastic refractories, mortars, etc.), a weighed sample of 100 g. shall be carefully transferred to a 500-cc. container, using a small jet of water from a ¼-in. rubber hose, and the test conducted as described in the wet method for dry material in Section 7.

(*c*) *Moisture Content of Wet Material.*—The moisture content of the wet material shall be immediately determined after opening the original container by weighing a 100-g. sample to the nearest 0.1 g. drying carefully at such a rate so as to finish the drying operation at a temperature of 120° C. after a period of 4 hours. Slow drying may be necessary in the case of cements containing sodium silicate or other cold-set bonds to prevent loss of the sample by the sudden escape of steam. The manipulation of cold-set cements may be facilitated by placing them on wax paper for drying. After drying, the sample shall again be weighed to the nearest 0.1 g. and the percentage of water calculated to the nearest 0.1 per cent.

Wet Sieve Analysis. 7. (*a*) The sample shall be placed in a container of about 500-cc. capacity, to which sufficient water shall be added to form a slurry. Slaking shall be allowed to proceed for 1 hour, after which a further addition of water may be necessary.

(*b*) The sample shall then be transferred to the finest sieve to be used in the analysis, and washed with water, using a small jet from a ¼-in. rubber hose. Washing the sample on the sieve shall be continued until the water passing through the sieve contains only traces of the sample. Care shall be exercised in the washing operation to prevent loss of the sample.

(*c*) The sieve containing the sample shall than be placed in an oven and dried at 120° C. for 2 hours. The sample shall then be weighed to the nearest 0.1 g., to determine the amount passing the finest sieve, after which it shall be transferred to the top, or coarsest, sieve of the series to be used in the analysis. The sieving shall then be conducted by machine or by hand in accordance with Section 4 (*a*) or (*b*).

Report. 8. The results of all sieve analyses shall be reported on the dry basis as the percentage passing the various sieves, and the calculations shall be reported to the nearest 0.1 per cent.

NOTE.—The Tyler standard series of sieves is widely used in the refractories industry. The more commonly used sieves are the Nos. 3, 4, 6, 8, 10, 14, 20, 28, 35, 48, 65, 100, 150 and 200. These sieves are within the tolerances[1] specified for a series of sieves in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[2] The subject of sieves is receiving consideration in a Sectional Committee on Sieves for Testing Purposes organized under the procedure of the American Standards Association.

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[1] Sieve No. 4 is the exception. The No. 4 sieve of Specifications E 11 has openings which are larger than the Tyler No. 4 sieve by 0.002 in.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

TENTATIVE SPECIFICATIONS
FOR
CLAY SEWER PIPE[1]

A.S.T.M. Designation: C 13 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover clay products intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class. 2. Sewer pipes furnished under these specifications shall be of single class to be designated "A.S.T.M. Clay Sewer Pipe."

MATERIAL AND MANUFACTURE

Materials. 3. (*a*) Clay pipes shall be manufactured from surface clay, fire clay, or shale, or a combination of these materials.

(*b*) *Surface clay* is an unconsolidated, unstratified clay,[2] occurring on the surface.

(*c*) *Fire clay* is a sedimentary clay[2] of low flux content.

NOTE.—It is usually associated with coal measures.

(*d*) *Shale* is a thinly stratified, consolidated sedimentary clay[2] with well marked cleavage parallel to the bedding.

(*e*) The materials shall possess such physical and chemical properties that when molded into pipes and subjected to a suitable temperature the product will be strong, durable and serviceable, free from objectionable defects, and conforming to these specifications.

RESISTANCE TO ACTION OF ACIDS

Resistance to Action of Acids. 4. When tested with either sulfuric, hydrochloric, nitric or acetic acid, the acid having a normality of one (1.0 *N*),[3] the resulting loss shall not exceed 0.25 per cent. The purpose of this test is to determine the resistance of pipe to the action of acids and its use is optional.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. S. Rankin, Secretary of Committee C-4 on Clay Pipe, Bureau of Sewers, City Hall, Newark, N. J.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Clay Sewer Pipe (A.S.T.M. Designation: C 13 - 24), 1930 Book of A.S.T.M. Standards, Part II, p. 227.

[2] The definitions for the terms "surface clay," "fire clay," and "shale" are based upon the following definition for the term "clay:"

Clay.—An earthy or stony mineral aggregate consisting essentially of hydrous silicates of alumina, plastic when sufficiently pulverized and wetted, rigid when dry and vitreous when burned at a sufficiently high temperature.

[3] The following percentages are required to make an acid of a normality of one: sulfuric acid, 4.90 per cent; hydrochloric acid, 3.65 per cent; nitric acid, 6.30 per cent; and acetic acid, 6.00 per cent.

Test Specimens. 5. (*a*) Where possible the specimens intended for these tests shall be selected from pipe which have previously been subjected to the crushing strength test. Specimens shall be sound with all edges freshly broken, free from cracks or shattered edges, about 2 in. square, not weighing more than 200 g. and shall be thoroughly cleaned with a wire brush.

Number of Tests. (*b*) A test shall be made on at least one specimen cut from each size of pipe. The results shall be reported separately for each individual specimen.

Weighing Apparatus. 6. The weighing shall be made on a balance accurate to 0.01 g.

Test Procedure. 7. (*a*) The specimens to be tested shall be dried to constant weight at a temperature of from 210 to 230° F.

(*b*) The specimens upon reaching constant weight shall be completely immersed in the test solution at a temperature of from 70 to 90° F. for a period of 48 hours then removed from the solution, carefully and thoroughly washed with hot water, allowing the washings to run into the solution in which the specimen was immersed. This solution shall then be evaporated nearly to dryness; transferred to a porcelain crucible (previously heated to constant weight) and heated to expel all fumes. The crucible shall then be cooled and its contents weighed.

(*c*) *Calculation.*—The weight of the residue on the porcelain crucible divided by the weight of the dry specimen before immersion multiplied by 100 is the percentage of loss.

$$\text{Percentage of loss} = \frac{\text{Wt. of residue in grams} \times 100}{\text{Wt. of dry specimen in grams}}$$

PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 8. The crushing strength and absorption of clay sewer pipe shall conform to the requirements given in Table I. The individual results of the various tests for each size of pipe and for each shipment shall be tabulated separately so as to show the percentage which fails to conform to the requirements of each test.

Test Specimens. 9. (*a*) The specimens for purpose of test shall be sound full-size pipe and shall be selected by the purchaser or his representative at a point or points designated by him when placing the order.

Number of Tests. (*b*) The manufacturer or seller shall furnish specimens for test, without charge, up to 0.5 per cent of the number of pipes in each size of pipe furnished, except that in no case shall less than two specimens be furnished.

Measurement and Observation of Specimens.

10. (*a*) The specimens shall first be freed from all visible moisture. When dry, each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded.

(*b*) *Defective Specimens.*—Specimens which are observed to have fire cracks or other defects in form or dimensions, in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

Crushing Strength Tests

Crushing Strength Tests.

11. Unless otherwise specified, pipe shall be tested for crushing strength by the three-edge-bearing method, but at the option of the purchaser, the knife or two-edge-bearing method may be used. However, in case of failure of the pipe to meet the requirements under the specified method, especially where the accuracy of the testing machine is questioned, a retest at the request of the manufacturer shall be made using the sand-bearing method.

TABLE I.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE.

Internal Diameter, in.	Average Crushing Strength, lb. per linear foot		Average Absorption, per cent
	Three-Edge-Bearing Method[1] and Knife or Two-Edge-Bearing Method[2]	Sand-Bearing Method[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8

[1] See Section 13. [2] See Section 14. [3] See Section 15.

Application of Load.

12. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The center of the load shall be applied to the top bearing block at a point distant from the spigot end of the pipe equal to one-half of the overall length of the pipe. The test load shall be applied to the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings. In testing pipe that is "out of straight" the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair test.

(*c*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*d*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum loads produced by the tests without lost motion, vibration or sudden shock.

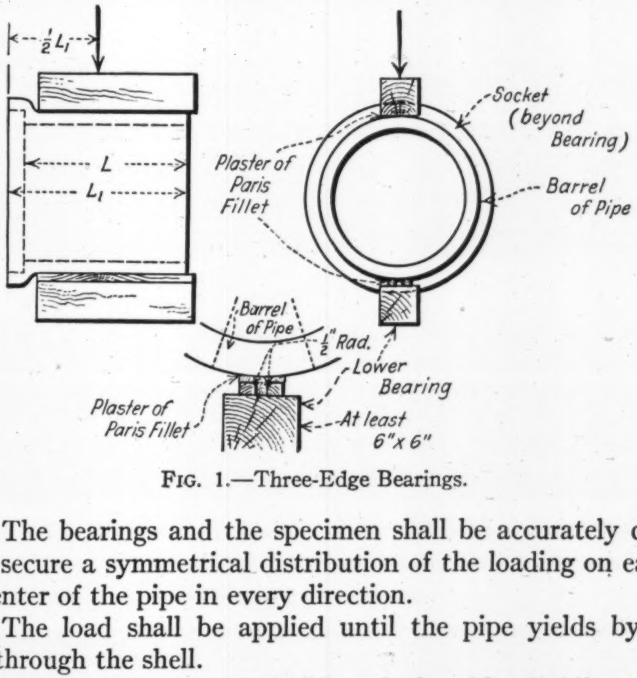


FIG. 1.—Three-Edge Bearings.

(*e*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

(*f*) The load shall be applied until the pipe yields by cracks passing through the shell.

(*g*) The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot.

Three-Edge-Bearing Method.

13. When the three-edge-bearing method (see Fig. 1) is used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test. The two lower bearings shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The

strips shall be straight and shall be securely fastened to a rigid block at least 6 by 6 in. in cross-section. The interior vertical sides of the strips shall be parallel and a distance apart not less than ½ in. nor more than 1 in. per foot of pipe diameter. Before the pipe is placed, a fillet of plaster of Paris thick enough to compensate for all the inequalities of the pipe barrel shall be cast on and between the two lower bearings. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The upper bearing shall be a rigid wooden block at least 6 by 6 in. in cross-section, straight and true from end to end. A fillet of plaster of Paris thick enough to compensate for the inequalities of the pipe barrel shall also be cast along the length of the crown. The upper bearing shall be brought in contact while the plaster of Paris is still somewhat plastic. The upper and lower bearings shall extend the full length of the pipe exclusive of socket.

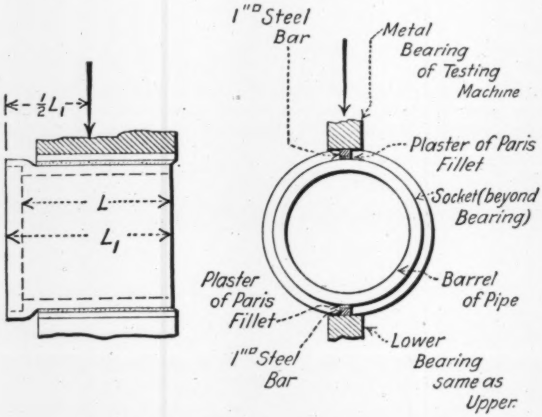


FIG. 2.—Knife or Two-Edge Bearings.

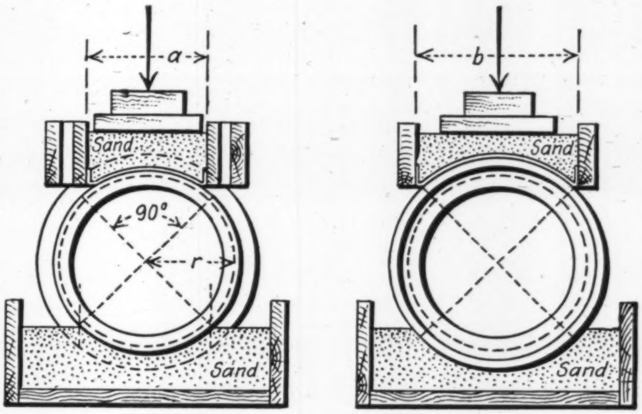
Knife or Two-Edge-Bearing Method.

14. When the knife or two-edge-bearing method (see Fig. 2) is used, the specimen shall be supported by a metallic knife bearing 1 in. in width which shall extend from the point just back of the socket to the spigot end of the pipe. Before the pipe is placed, a fillet of plaster of Paris thick enough to compensate for all the inequalities of the pipe barrel shall be cast on the lower bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The upper knife bearing shall be of the same size and length as the lower bearing. A fillet of plaster of Paris 1 in. in width and thick enough to compensate for all the inequalities of the pipe barrel shall be cast along the length of the crown. The upper bearing shall be brought in contact while the plaster of Paris is still somewhat

plastic. The upper and lower bearings shall extend the full length of the pipe exclusive of socket.

Sand-Bearing Method.

15. When the sand-bearing method (see Fig. 3) is used the ends of each specimen of pipe shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.


a
Sand
90°
r
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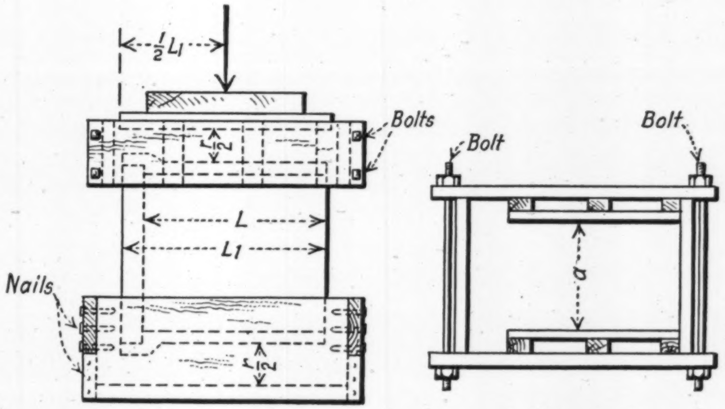
Bedding of Barrel.

Bedding of Socket.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Bolts
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Side View.

Upper Bearing Frame.

FIG. 3.—Sand Bearings.

The sand used shall be clean and moist, and shall be such as will pass a 4760-micron (No. 4) sieve.[1] The sand in the lower bearing shall be loose when the pipe is placed.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck off level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Absorption Test

Test Specimens. 16. (*a*) The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing strength tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

Identification. (*b*) Each specimen shall be marked so that it may be identified with the pipe used in the crushing strength test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

Number of Tests. (*c*) One specimen shall be tested of each pipe broken in the crushing strength test.

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[1] For requirements for this sieve, see Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

17. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest 1 g. When other than metric weights are used, the same degree of accuracy shall be obtained. **Weighing Apparatus.**

18. (*a*) *Drying.*—Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25° C. (68 to 77° F.), and then reweighed. **Procedure.**

If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a further drying treatment of two hours and reweighed. If the third weight checks the second the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for two-hour periods, until check weights are obtained.

(*b*) *Immersion.*—The specimen, after final drying, cooling and weighing, shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

(*c*) *Reweighing.*—The specimen shall be allowed to drain for one minute, and the superficial moisture having been removed by towel or blotting paper, placed upon the balance and weighed.

19. The absorption shall be calculated as percentage of the initial dry weight. The results shall be reported separately for each individual specimen, together with the mean for all the specimens from the same shipment of pipe. **Calculation and Reporting of Results.**

20. (*a*) Failure of 20 per cent of the specimens to meet the requirements of crushing strength and absorption tests shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the purchaser, furnish for test, without charge, additional specimens from the same shipment. In case more than 80 per cent of the specimens tested, including those first tested, shall show substantial conformance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected. **Acceptance or Rejection on Results of Test.**

(*b*) In addition to the requirements in Paragraph (*a*), failure of 10 per cent or more of the individual specimens tested to develop 75 per cent of the average crushing strength requirements shall be cause for the rejection of the shipment, but the manufacturer or seller may cull the pipe and submit the balance of the shipment for retest, and if the shipment then conforms to all of the requirements of these specifications it shall be accepted.

TABLE II.—DIMENSIONS OF CLAY SEWER PIPE.[a]

Internal Diameter (D), in.	Laying Length (L), ft.	Inside Diameter at $\frac{1}{2}$ in. Above Base of Socket (D_S), in.[b]	Depth of Socket (L_s), in.	Minimum Taper of Socket (H)	Thickness of Barrel (T), in.	Thickness of Socket (T_s)
4..............	2	$5\frac{7}{8}$	$1\frac{3}{4}$	1:20	$\frac{1}{2}$	The thickness of the socket $\frac{1}{4}$ in. from its outer end shall be not less than three-fourths of the thickness of the barrel of the pipe.
6..............	2, $2\frac{1}{2}$	$8\frac{1}{8}$	$2\frac{1}{4}$	1:20	$\frac{5}{8}$	
8..............	2, $2\frac{1}{2}$, 3	$10\frac{5}{8}$	$2\frac{1}{2}$	1:20	$\frac{3}{4}$	
10..............	2, $2\frac{1}{2}$, 3	$12\frac{7}{8}$	$2\frac{1}{2}$	1:20	$\frac{7}{8}$	
12..............	2, $2\frac{1}{2}$, 3	$15\frac{1}{4}$	$2\frac{1}{2}$	1:20	1	
15..............	2, $2\frac{1}{2}$, 3	$18\frac{5}{8}$	$2\frac{1}{2}$	1:20	$1\frac{1}{4}$	
18..............	2, $2\frac{1}{2}$, 3	$22\frac{1}{4}$	3	1:20	$1\frac{1}{2}$	
21..............	2, $2\frac{1}{2}$, 3	$25\frac{3}{4}$	3	1:20	$1\frac{3}{4}$	
24..............	2, $2\frac{1}{2}$, 3	$29\frac{3}{8}$	3	1:20	2	
27..............	$2\frac{1}{2}$, 3	33	$3\frac{1}{2}$	1:20	$2\frac{1}{4}$	
30..............	$2\frac{1}{2}$, 3	$36\frac{5}{8}$	$3\frac{1}{2}$	1:20	$2\frac{1}{2}$	
33..............	$2\frac{1}{2}$, 3	$39\frac{7}{8}$	4	1:20	$2\frac{5}{8}$	
36..............	$2\frac{1}{2}$, 3	$43\frac{5}{8}$	4	1:20	$2\frac{3}{4}$	

[a] Applications of dimensions given in this table are shown in Fig. 4.

[b] When pipes are furnished having an increase in thickness over that given in last column, the diameter of socket shall be increased by an amount equal to twice the increase of thickness of barrel.

TABLE III.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF CLAY SEWER PIPE.

Nominal Size, Internal Diameter, in.	Limits of Permissible Variation in:					
	Length, in. per ft. (−)	Lengths of Two Opposite Sides, in.	Internal Diameter, in.		Depth of Socket, in. (−)	Thickness of Barrel, in. (−)
			Spigot (±)	Socket (±)		
4..............	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
6..............	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
8..............	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
10..............	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
12..............	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{16}$
15..............	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$
18..............	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{32}$
21..............	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
24..............	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
27..............	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
30..............	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
33..............	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
36..............	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{16}$

NOTE.—The minus sign (−) alone indicates that the plus variation is not limited, the plus and minus sign (±) ndicates variation in both excess and deficiency in dimension.

A.S.T.M. SIZES, DIMENSIONS AND PERMISSIBLE VARIATIONS

Sizes and Dimensions.

21. Pipes shall be furnished of the sizes, internal diameter, and with the dimensions given in Table II. Where several lengths are mentioned in the table the consumer or purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

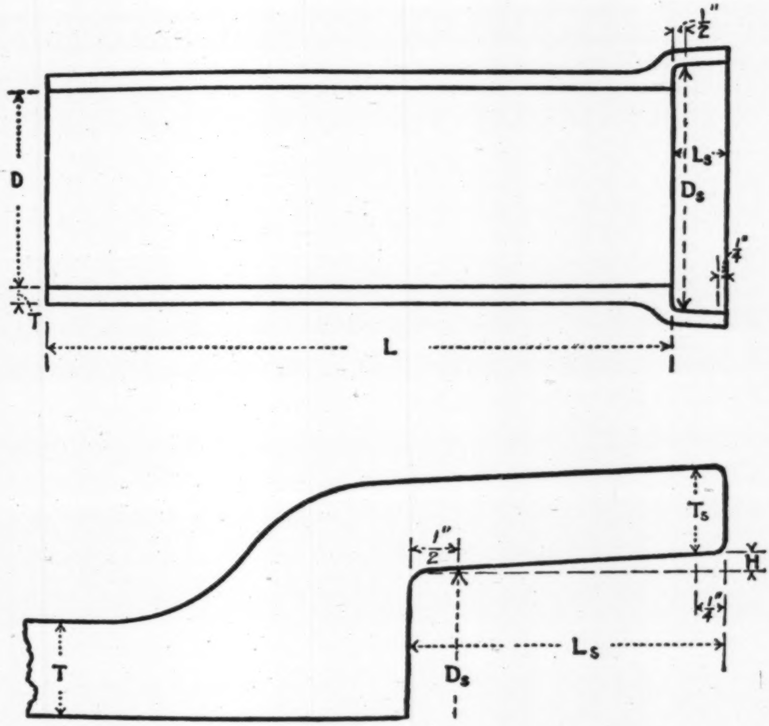

FIG. 4.—Applications of Dimensions Given in Table II.

Permissible Variations.

22. The permissible variations from the dimensions given in Table II shall not exceed those specified in Table III. Where the thickness of barrel is increased beyond that given in Table III in order to meet the specified requirements of strength, the diameter at inside of socket shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than ⅛ in. per foot of length. This measurement to mean the maximum ordinate as measured from the concave side of the pipe.

WORKMANSHIP AND FINISH

Absence of Defects. 23. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Salt Glaze. 24. The glaze shall consist of a continuous layer of salt glaze substantially free from large blisters or large pimples. No blisters shall exceed 3 in. in diameter and no blisters or pimples shall project more than $\frac{1}{8}$ in. above the surrounding surface of the pipe for sizes up to and including 18 in. internal diameter. For sizes over 18 in. internal diameter no blisters shall exceed in diameter more than 2 in. per foot of the internal diameter of the pipe, nor project above the surrounding surface of the pipe more than $\frac{1}{8}$ in. per foot of the internal diameter of the pipe.

Not more than 10 per cent of the inner surface of any pipe barrel shall be bare of glaze except the socket, where it may be entirely absent. Glazing shall not be required on the outer surface of the barrel at the spigot end for a distance from the end of the pipe equal to the specified depth of socket. There shall be no well defined network of crazing lines or hair cracks.

Finish of Ends. 25. The ends of the pipes shall be square with their longitudinal axis, except as provided in Table III.

Fittings. 26. (*a*) Fittings shall have a plain spigot end and a socket end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branch pipes shall be furnished to lay the same lengths as straight pipe. All fittings shall conform in finish to the specifications for pipe given in Sections 23, 24, and 25.

(*b*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*c*) Curves shall be at angles of 90 and 45 deg., as required. They shall conform substantially to the curvature specified.

(*d*) Branches shall be furnished with the spur or spurs of the size or sizes specified, securely and completely fastened in the process of manufacture, to the barrel of the pipe. T-branches and double T-branches shall have their axes perpendicular to the longitudinal axis of the pipe. Y-branches and double Y-branches shall have their axes approximately 60 deg. from the longitudinal axis of the pipe measured from the socket end. All spurs shall terminate in sockets and the barrel of the spurs shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the spur socket.

(*e*) Channel or split pipes, curves and branches shall be approximate half sections of the corresponding size of straight pipe and fittings.

MARKING

27. All pipe over 6 in. in diameter shall bear the initials or name of the person, company or corporation by whom manufactured, and the location of the mill. The markings shall be indented on the exterior of the pipe near the socket and shall be plainly legible for purposes of identification. **Marking.**

INSPECTION AND REJECTION

28. All pipes shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to conform to the requirements of these specifications. **Inspection.**

29. Pipes shall be subject to rejection on account of the following: **Rejection.**

(*a*) Variations in any dimension exceeding the permissible variations given in Table III.

(*b*) Fractures or cracks passing through the shell or socket, except that a single crack at the spigot end of the pipe not exceeding 75 per cent of the depth of the socket, or a single fracture in the socket not exceeding 3 in. in width nor 2 in. in length.

(*c*) Chips or fractures on the interior of the pipe exceeding 2 in. in length, 1 in. in width, and of a depth more than one-quarter of the thickness of the shell.

(*d*) Blisters which are broken or which exceed the dimensions specified in Section 24.

(*e*) Fire cracks or hair cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than $\frac{1}{8}$ in. per linear foot in alignment of a pipe intended to be straight.

(*g*) Glaze which does not conform with these specifications as specified in Section 24.

(*h*) Insecure attachment of spurs on branches.

30. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the purchaser. **Marking of Rejected Specimens.**

TENTATIVE SPECIFICATIONS

FOR

PURE LINSEED OIL PUTTY FOR GLAZING[1]

A.S.T.M. Designation: D 317 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1930; Revised, 1932.

Scope. 1. These specifications cover two classes of putty for glazing and similar purposes, as follows:

Class A.—Whiting putty.

Class B.—White lead whiting putty.

The putty shall be furnished in natural color, or tinted or colored as specified by the purchaser.

MANUFACTURE

Process. 2. The putty shall be made by thoroughly grinding or "chasing" the specified dry pigment with pure linseed oil to a dough-like paste of proper consistency.

PROPERTIES AND TESTS

Pigment. 3 (*a*) The dry pigment shall conform to the following requirements:

	Whiting Putty	White-Lead Whiting Putty
Calcium Carbonate, minimum, per cent	95	..
White lead, minimum, per cent	..	10
Total calcium carbonate and white lead, minimum, per cent	..	95
Tinting pigment plus impurities, maximum, per cent	5	5

(*b*) *Whiting.*—The whiting used in both classes of putty shall be a finely-powdered natural chalk of high grade. It shall be free from grit and be practically neutral. It shall have the structure and other physical characteristics of the best natural whiting suitable for putty making.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

(*c*) *White-Lead.*—The white lead shall be pure, basic lead carbonate.

(*d*) *Tinting Pigment.*—Tinting or coloring pigments, if used, shall be pure and be used in minimum quantity to secure the specified tint or shade.

Linseed Oil. 4. The liquid shall consist entirely of pure linseed oil.

Finished Putty. 5. (*a*) The finished putty shall conform to the following requirements:

	Whiting Putty		White-Lead Whiting Putty	
	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
Pigment, per cent	88	..	88	..
Pure linseed oil, per cent	..	12	..	12
Moisture and other volatile matter, per cent	0.5	..	0.5	..
Alkalinity (to boiling water) calculated as calcium carbonate, per cent	0.1	..	0.1	..
Coarse particles and skins (total residue retained on a No. 200 sieve[1]) per cent of the dry pigment	3.0	..	3.0	..

(*b*) The finished putty, after working in the hands, shall have good plastic quality without sticking to the hands. It shall work readily and smoothly under a knife without crumbling or cracking. After being molded in place it shall hold its shape until set.

(*c*) Tinted or colored putty shall match, in tint or color, a sample mutually agreed upon by buyer and seller.

(*d*) The putty, as received, shall not be caked or hardened in the container.

Number of Samples. 6. One sample shall be taken at random from each lot of 10,000 lb. or fraction thereof.

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[1] For determining coarse particles and skins, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

TENTATIVE SPECIFICATIONS
FOR
ETHYLENE GLYCOL MONO BUTYL ETHER[1, 2]

A.S.T.M. Designation: D 330 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Properties. 1. Ethylene glycol mono butyl ether shall conform to the following requirements:

Specific gravity, 20°/20° C	0.899 to 0.905
Color	water white
Distillation range:[a]	
Below 163° C	none
Below 167° C	not more than 5 per cent
Below 171° C	not less than 95 per cent
Above 174° C	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	mild, non-residual
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20° C.
Acidity (free acid as acetic acid)	not more than 0.2 mg. KOH per gram of sample

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[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, –5 to +300° C., +20 to +580° F. (A.S.T.M. Designation: D 183) of the American Society for Testing Materials.[3]

Methods of Testing. 2. The sampling and methods of testing shall be conducted in accordance with the Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268 – 31 T) of the American Society for Testing Materials.[4]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] This compound is also known under the names beta butoxy ethanol and butyl glycol.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1115.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 799 (1931): also 1932 Book of A.S.T.M. Tentative Standards, p. 516.

TENTATIVE SPECIFICATIONS

FOR

ETHYLENE GLYCOL MONO ETHYL ETHER[1, 2]

A.S.T.M. Designation: D 331 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Properties.

1. Ethylene glycol mono ethyl ether shall conform to the following requirements:

Specific gravity, 20°/20° C	0.927 to 0.933
Color	water white
Distillation range:[a]	
Below 128° C	none
Below 132° C	not more than 5 per cent
Below 136° C	not less than 95 per cent
Above 137° C	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	mild, non-residual
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20° C.
Acidity (free acid as acetic acid)	not more than 0.2 mg. KOH per gram of sample

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[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150° C., 0 to +300° F. (A.S.T.M. Designation: D 182) of the American Society for Testing Materials.[3]

Methods of Testing.

2. The sampling and methods of testing shall be conducted in accordance with the Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268 - 31 T) of the American Society for Testing Materials.[4]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] This compound is also known under the names beta ethoxy ethanol and ethyl glycol.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1113.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 799 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 516.

TENTATIVE SPECIFICATIONS
FOR
ACETATE ESTER OF ETHYLENE GLYCOL MONO ETHYL ETHER (90 TO 91 PER CENT GRADE)[1, 2]

A.S.T.M. Designation: D 342 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Properties. 1. The acetate of ethylene glycol mono ethyl ether (90 to 91 per cent grade) shall conform to the following requirements:

Specific gravity, 20°/20° C	0.966 to 0.974
Color	not darker than a solution of 0.008 g. potassium dichromate per liter of water
Distillation range:[a]	
Below 140° C	none
Between 145° and 160° C	not less than 90 per cent
Above 165° C	none
Non-volatile matter	not more than 0.03 g. per 100 ml.
Odor	mild, non-residual
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20° C.
Acidity (free acid as acetic acid)	not more than 0.024 per cent, equivalent to 0.2 mg. KOH per gram of sample
Ester value	90 to 91 per cent by weight

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[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +300° C., +20 to +580° F. (A.S.T.M. Designation: D 183) of the American Society for Testing Materials.[3]

Methods of Testing. 2. The sampling and methods of testing shall be conducted in accordance with the Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268 - 31 T) of the American Society for Testing Materials.[4]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] This compound is also known under the names beta ethoxy ethyl acetate and ethyl glycol acetate.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1115.

[4] *Proceedings,* Am. Soc. Testing Mats., Vol. 31, Part I, p. 799 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 516.

TENTATIVE SPECIFICATIONS

FOR

ACETATE ESTER OF ETHYLENE GLYCOL MONO ETHYL ETHER (95 TO 96 PER CENT GRADE)[1, 2]

A.S.T.M. Designation: D 343 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Properties.

1. The acetate of ethylene glycol mono ethyl ether (95 to 96 per cent grade) shall conform to the following requirements:

Specific gravity, 20°/20° C	0.968 to 0.976
Color	not darker than a solution of 0.008 g. potassium dichromate per liter of water
Distillation range:[a]	
Below 145° C	none
Between 150 and 160° C	not less than 90 per cent
Above 165° C	none
Non-volatile matter	not more than 0.03 g. per 100 ml.
Odor	mild, non-residual
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20° C.
Acidity (free acid as acetic acid)	not more than 0.024 per cent, equivalent to 0.2 mg. KOH per gram of sample
Ester value	95 to 96 per cent by weight

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[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +300° C., +20 to +580° F. (A.S.T.M. Designation: D 183) of the American Society for Testing Materials.[3]

Methods of Testing.

2. The sampling and methods of testing shall be conducted in accordance with the Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268 - 31 T) of the American Society for Testing Materials.[4]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] This compound is also known under the names beta ethoxy ethyl acetate and ethyl glycol acetate.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1115.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 799 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 516.

TENTATIVE METHODS OF TESTING NITROCELLULOSE CLEAR LACQUERS AND LACQUER ENAMELS[1]

A.S.T.M. Designation: D 333 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931; REVISED, 1932.

Weight per Gallon.

1. (*a*) The weight in pounds per U. S. gallon shall be obtained by multiplying the specific gravity by 8.32. The specific gravity shall be determined by any convenient method that is accurate to the second decimal place, the temperature of both sample and water being 20° C.

(*b*) *Mobile Liquids.*—For sufficiently mobile liquids a convenient apparatus is an accurately calibrated volumetric flask. Fill to the mark at 20° C. and weigh accurately. Apply the following equation:

$$\text{Sp. gr.} = \frac{\text{Weight in grams of contents}}{\text{Capacity in milliliters}}$$

(*c*) *Viscous Materials.*—For very viscous materials which cannot be conveniently introduced into a volumetric flask, any convenient vessel of known capacity may be used. A suitable apparatus is described in the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[2]

Drying Time.

2. The sample and a mutually agreed upon standard shall be flowed without thinning, crosswise on a clean 4 by 8-in. glass plate and examined for drying and hardening at specified periods such as 3 minutes, 15 minutes, 1 hour, and 24 hours. The drying shall be judged by touching or pressing the films with the finger at approximately the same points.

Color.

3. A panel for the color test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque surface in such a manner that the two materials shall flow together along

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] **1930 Book of A.S.T.M. Standards, Part II, p. 664.**

adjacent edges. The background shall be a mutually agreed upon material. A preliminary examination may be made after 1 hour, but the final examination shall not be made until 24 hours after pouring.

Gloss. 4. The panel prepared for the color test in accordance with Section 3 shall be examined after 24 hours for gloss. A convenient method of determining apparent gloss is to hold the test panel at an angle of incidence approaching 180 deg. to a source of artificial light and to note the comparative sharpness of the definition of the image (for example, the lamp filament).

Homogeneity. 5. The sample shall be thinned with the thinner recommended, in the proportions recommended. The thinned sample shall be flowed on a glass panel and dried in a dust-free atmosphere. The panel shall be examined by reflected and transmitted light for pigment dispersion and freedom from particles of foreign matter.

Print Test. 6. The test panel for the print test shall be prepared in a manner mutually agreed upon by the buyer and seller. The test panel shall be covered with two pieces of ordinary cheesecloth over which shall be placed a piece of felt about $\frac{3}{32}$ in. in thickness. A known uniform pressure shall then be applied to the felt, over a circular area of at least 1 in. in diameter for a given length of time. The time allowed for the lacquer to dry before applying the pressure shall be also predetermined.

Tests shall be made under definite, predetermined conditions of temperature and humidity or, if this is not possible, a standard shall be run at the same time.

Bending Test. 7. The composition of the metal test panel for the bending test, the gage thereof and the manner of application of lacquer coating applied thereto, shall be mutually agreed upon by the buyer and seller.

The test shall be made by bending the panel at a uniform rate through an angle of more than 140 deg. over a mandrel of mutually agreed upon radius.

Outdoor Exposure. 8. At least two test panels shall be exposed outdoors on an exposure rack, in full sunlight, at an angle of 45 deg. from the vertical facing south, and examined at regular intervals for color, gloss, etc., and compared with a standard panel prepared and exposed in a manner mutually agreed upon by the buyer and seller.

Non-Volatile Matter. 9. Weigh into an aluminum dish containing a stirring rod, from 4 to 6 g. of the sample to be tested. Pour in 100 ml. of acetone and stir until solution of material is complete. Add slowly 10 ml. of water, stirring vigorously. Place the dish on a hot-water bath and allow the solution to evaporate to dryness. Heat for 1 hour in an oven at 100 to 105° C. Allow to cool 20 minutes in a desiccator and weigh. (The dish should be covered in such a manner as to allow solvents to escape and exclude contamination by dirt in the atmosphere.) If the precipitate or residue is lumpy, redissolve in the solvent combination and precipitate again with water.

The method of determining non-volatile matter in varnishes, as described in Sections 6 and 7 of the Standard Methods of Testing Oleo-Resinous Varnishes (A.S.T.M. Designation: D 154) of the American Society for Testing Materials,[1] may be used if mutually agreed upon by the buyer and seller.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 357.

TENTATIVE METHOD OF TEST
FOR
COMPARATIVE HIDING POWER OF PAINTS[1]

A.S.T.M. Designation: D 344 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1932.

Scope.

1. This method is intended for determining the hiding power of paints in square feet per U. S. gallon. The point of complete hiding is dependent on individual opinion and is, therefore, subject to some variation between different laboratories. This method, however, gives satisfactory results when two paints are compared under identical conditions by the same operator.

Definition.

2. The definition of hiding power as it appears in the Standard Definitions of Terms Relating to Paint Specifications (A.S.T.M. Designation: D 16) of the American Society for Testing Materials[2] is as follows:

Hiding Power.—The power of a paint or paint material as used to obscure a surface painted with it.

Note.—In this definition the word "obscure" means to render invisible or to cover up a surface so that it cannot be seen.

Measure of Hiding Power.

3. The measure of hiding power is that area[3] of surface (as specified below) which can be obscured by a unit volume[3] of paint, when spread evenly over that surface.

It is understood that uncontrolled variables render the results comparative rather than absolute.

It shall be specified whether the results refer to the wet paint or the dry film.

Apparatus.

4. The apparatus shall consist of the following:

(*a*) *Painting Surface.*—A fairly smooth, impervious surface of not less than one square foot composed of alternate black (not more than 8 per cent brightness) and white (not less than 75 per cent brightness) areas.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 441.

[3] For uniformity, this property is expressed in square feet per U. S. gallon.

NOTE.—A square or rectangular surface, the shortest side of which is about 24 in. composed of alternate white and black squares, 2, 4 or 6 in. on a side is a convenient form.

(*b*) *Paint Brush.*—A good paint brush.

(*c*) *Scale.*—A counter scale capable of weighing the paint sample to within 1 g.

(*d*) *Illumination.*—A means of obtaining constant illumination, preferably approximating Northern sky light.

Specific Gravity and Weight Determination.

5. The specific gravity or the weight in pounds per gallon of the sample to be tested shall be determined by any convenient method.[1] The weight of the can with paint and brush shall then be determined in grams.

Procedure.

6. (*a*) *Wet Hiding Power.*—The paint shall be applied with the brush to the black and white surface, brushing as uniformly as possible over the black and white squares until no difference in brightness, when viewed normally, can be detected between the black and white areas. The sample (can, paint and brush) shall again be weighed and the hiding power per unit calculated from the amount of paint used.

NOTE.—Precautions should be taken to insure minimum loss of volatile matter.

(*b*) *Dry Hiding Power.*—The paint shall be applied with the brush in thin even coats to the black and white surface. The weight of paint in grams used for each coat shall be determined, and ample time between coats shall be allowed for drying. Successive coats shall be applied and dried until the contrast between the black and white areas is obliterated.

Calculation.

7. The hiding power, expressed in square feet per U. S. gallon, shall be calculated from either of the following formulas:

$$H = \frac{\text{sp. gr.} \times 3785 \times A}{G}$$

or

$$H = \frac{W \times 454 \times A}{G}$$

where H = the hiding power in square feet per U. S. gallon;

A = the area of black and white surface in square feet;

sp. gr. = the specific gravity of the paint;

W = the weight of the paint in pounds per U. S. gallon; and

G = the weight of paint in grams applied to area A.

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[1] Method described in Gardner's Laboratory Manual, p. 654, is recommended.

TENTATIVE METHOD OF TEST
FOR
COLOR OF LUBRICATING OILS BY MEANS OF A.S.T.M. UNION COLORIMETER[1]

A.S.T.M. Designation: D 155 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1923; REVISED, 1932.

Scope. 1. The color of lubricating oil shall be determined by means of the A.S.T.M. Union Colorimeter.

APPARATUS

Apparatus. 2. (*a*) The A.S.T.M. Union Colorimeter shall bear a metal name plate marked with the following description and a serial number:

A.S.T.M. UNION COLORIMETER
Licensed under U. S. Patent No. 1,495,763.

(*b*) The A.S.T.M. Union Colorimeter, Fig. 1, shall consist of a box, *a*, a glass jar, a light shield, *b*, and a daylight lamp, *c*. A magazine containing the glass color standards shall be an integral part of the box.

Box. (*c*) The box, *a*, Fig. 1, shall be constructed of metal or wood and shall be approximately 18 in. (457 mm.) in length. The approximate inside dimensions shall be $1\frac{1}{2}$ in. (38 mm.) in depth, $2\frac{1}{8}$ in. (54 mm.) in width at the observation end and 3 in. (76 mm.) in width at the illumination end. The box shall have an interior finish of dull black and shall be so constructed as to preclude the entrance of any extraneous light.

A transverse vertical partition with a centrally-located opening $\frac{1}{2}$ in. (13 mm.) in diameter shall be placed $1\frac{1}{8}$ in. (28 mm.) from the observation end of the box. A second transverse vertical partition shall be placed so that the side nearer the illumination end shall be approximately $2\frac{1}{8}$ in. (54 mm.) from that end. This partition shall be approximately 1 in. (25 mm.) thick and shall have in the left half a vertical aperture in which the magazine, containing the glass color standards, is mounted. This partition shall have two horizontal openings approximately $\frac{9}{16}$ in. (14 mm.) in diameter at the observation end and $\frac{3}{4}$ in. (19 mm.) in diameter at the illumination end located midway between the top and the bottom of the partition. The openings shall be spaced $1\frac{1}{2}$ in. (38 mm.) between centers and located symmetrically in regard to the center line. Suitable mechanism shall be provided for raising and lowering the magazine. An opening shall be located in the left side of the box to permit the reading, by means of a mirror, of the color numbers stamped, as mirror images, on the side of the magazine. A pure white opal glass approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in. (82 by 44 by 1.75 mm.) shall be mounted across the illumination end of the box. The glass shall be ground or etched on the inner side to diffuse light rays. A vertical partition, approximately $\frac{1}{8}$ in. (3 mm.) in thickness, shall extend along the horizontal axis of the box from the opal glass to the transverse partition which contains the magazine. This partition divides the illumination end of the box into two compartments. In the top of the box, centrally-located

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

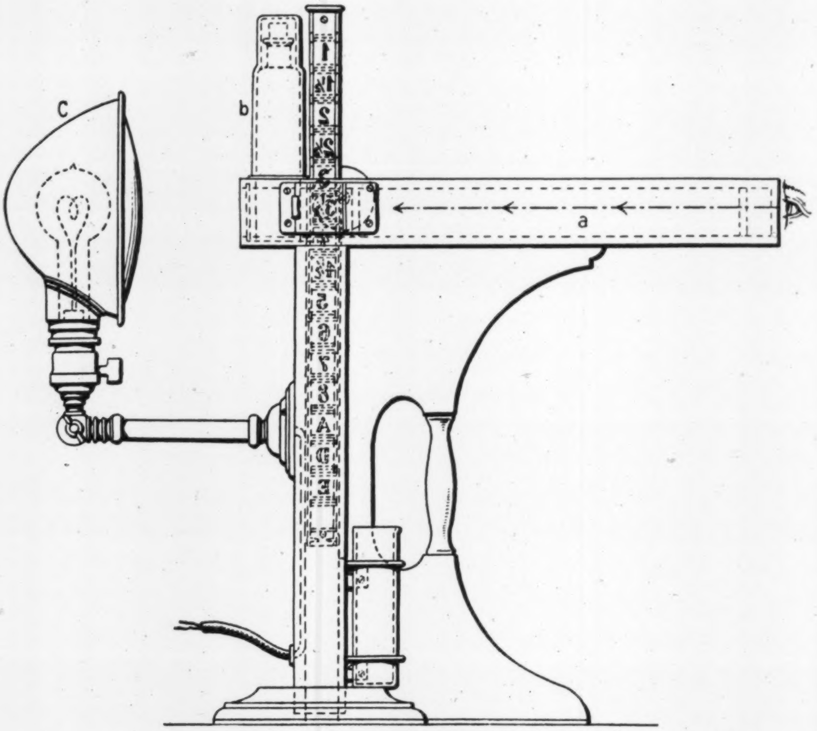

FIG. 1.—A.S.T.M. Union Colorimeter.

over these two compartments, there shall be circular openings of such size as to accommodate the standard jar and 4-oz. sample bottles.

Color Standards. (*d*) The glass color standards shall be 12 in number as specified in Table I. These glasses shall be mounted in a magazine. The magazine shall have an additional opening containing no glass standard so that two bottles of oil may be compared in the colorimeter. The width of the glass color standards shall be not less than $\frac{5}{8}$ in. (16 mm.).

Glass Test Jar. (*e*) The standard glass jar, Fig. 2, shall be a true cylinder of clear colorless glass. The internal diameter shall be not less than $1\frac{9}{32}$ in. (32.5 mm.) nor more than $1\frac{5}{16}$ in. (33.5 mm.). The thickness of the wall shall be $\frac{1}{16}$ in. ± $\frac{1}{64}$ in. (1.75 mm. ± 0.25 mm.). The height of the cylinder shall be 5 in. ± $\frac{1}{4}$ in. (127 mm. ± 6 mm.).

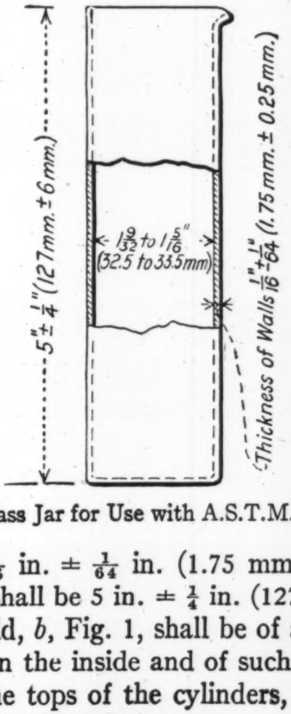
5" ± 1/4" (127 mm. ± 6 mm.)
1 9/32 to 1 5/16"
(32.5 to 33.5mm)
Thickness of Walls 1/16" ± 1/64" (1.75 mm. ± 0.25 mm.)

FIG. 2.—Standard Glass Jar for Use with A.S.T.M. Union Colorimeter.

Light Shield. (*f*) The light shield, *b*, Fig. 1, shall be of any suitable material. It shall be dull black on the inside and of such size as to shield completely all light from the tops of the cylinders, or oil sample bottles, when they are in place in the colorimeter.

Artificial Daylight Lamp. (*g*) The artificial daylight lamp, *c*, Fig. 1, may for convenience be fastened to the base supporting the box. It shall consist of a 60-watt A-21 Mazda daylight lamp, fitting into a socket equipped with a parabolic metal reflector and mounted on a swivel. The inside of this reflector shall be brightly finished at all times with bright aluminum paint or brightly polished silver or nickel. In the front of the reflector shall be mounted a dished, but not lenticular, glass color screen of such composition and color as, in conjunction with the A-21

Mazda daylight lamp, will yield by spectrum analysis a light closely approximating Northern daylight. When in normal position, the color screen shall be 4 in. (102 mm.) from the white opal glass.

The artificial daylight lamp shall be used for referee work. In case electric current is not available, the colorimeter may be used by exposing the opal glass to Northern daylight with no colored objects in the immediate foreground.

PROCEDURE

Oils not Darker than 8 Color.

3. Oil not darker than 8 color, when examined, shall be at room temperature unless its cloud point is above the temperature of the room, in which case the oil shall be heated to a temperature of not more than 10° F. above its cloud point. The oil to be examined may be observed in the ordinary 4-oz. sample bottle, but in referee work a standard jar shall be used. The jar shall be placed in the right-hand compartment while in the other compartment shall be placed a 4-oz. sample bottle of distilled water. The jar and bottle shall be covered with the shield, and the artificial daylight lamp lighted. The color of the oil is obtained by determining the glass color standard which most nearly matches the color of the oil under examination. The colors of oils which are intermediate to the standard colors may be expressed in terms of the darker standard as "lighter than" or "minus."

TABLE I.—GLASS COLOR STANDARDS OF A.S.T.M. UNION COLORIMETER.

A.S.T.M. Color Numbers	National Petroleum Association Color Numbers	National Petroleum Association Names	Lovibond Analysis		
			Red 200 Series	Yellow 510 Series	Blue 1180 Series
1	No. 1 N.P.A.	Lily White	0.12	2.4	....
1½	No. 1½ N.P.A.	Cream White	0.60	8.0	....
2	No. 2 N.P.A.	Extra Pale	2.5	26.0	....
2½	No. 2½ N.P.A.	Extra Lemon Pale	4.6	27.0	....
3	No. 3 N.P.A.	Lemon Pale	6.9	32.0	....
3½	No. 3½ N.P.A.	Extra Orange Pale	9.4	45.0	....
4	No. 4 N.P.A.	Orange Pale	14.0	50.0	0.55
4½	No. 4½ N.P.A.	Pale	21.0	56.0	0.55
5	No. 5 N.P.A.	Light Red	35.0	93.0	....
6	No. 6 N.P.A.	Dark Red	60.0	60.0	0.55
7	No. 7 N.P.A.	Claret Red	60.0	106.0	1.8
8	No. 8 N.P.A.	....	166.0	64.0	....

NOTE: *Example.*—When an oil has a color between 7 and 8, the color may be expressed as "lighter than 8" or "8 minus."

The daylight lamp may be brought closer to the opal glass in determining the darker colors.

Oils Darker than 8 Color

4. Oils darker than 8 color shall be diluted with kerosine. The color of the kerosine shall be not darker than +21 as determined in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (A.S.T.M. Designation: D 156 – 23 T) of the American Society for Testing Materials.[1] A mixture of exactly 15 per cent by volume of oil, and 85 per cent by volume of kerosine shall be used in all cases. The color of the mixture shall be obtained in accordance with the procedure described in Section 3.

The numbers designating the color of all oils which have been diluted to make the determination shall be followed by the designation "Dil."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 682 (1923)· also 1932 Book of A.S.T.M. Tentative Standards, p. 557.

TENTATIVE METHOD OF TEST
FOR
COLOR OF PETROLATUM BY MEANS OF A.S.T.M. UNION COLORIMETER[1]

A.S.T.M. Designation: D 218 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1925; Revised, 1932.

Scope. 1. The color of petrolatum shall be determined by means of the A.S.T.M. Union Colorimeter.

Apparatus

Apparatus. 2. (*a*) The A.S.T.M. Union Colorimeter shall bear a metal name plate marked with the following description and a serial number:

A.S.T.M. Union Colorimeter
Licensed under U. S. Patent No. 1,495,763.

(*b*) The A.S.T.M. Union Colorimeter, Fig. 1, shall consist of a box, *a*, a glass jar, a light shield, *b*, and a daylight lamp, *c*. A magazine containing the glass color standards shall be an integral part of the box.

Box. (*c*) The box, *a*, Fig. 1, shall be constructed of metal or wood and shall be approximately 18 in. (457 mm.) in length. The approximate inside dimensions shall be $1\frac{1}{2}$ in. (38 mm.) in depth, $2\frac{1}{8}$ in. (54 mm.) in width at the observation end and 3 in. (76 mm.) in width at the illumination end. The box shall have an interior finish of dull black and shall be so constructed as to preclude the entrance of any extraneous light.

A transverse vertical partition with a centrally-located opening $\frac{1}{2}$ in. (13 mm.) in diameter shall be placed $1\frac{1}{8}$ in. (28 mm.) from the observation end of the box. A second transverse vertical partition shall be placed so that the side nearer the illumination end shall be approximately $2\frac{1}{8}$ in. (54 mm.) from that end. This partition shall be approximately 1 in. (25 mm.) thick and shall have in the left half a vertical aperture in which the magazine, containing the glass color standards, is mounted. This partition shall have two horizontal openings approximately $\frac{9}{16}$ in. (14 mm.) in diameter at the observation end and $\frac{3}{4}$ in. (19 mm.) in diameter at the illumination end located midway between the top and the bottom of the partition. The openings shall be spaced $1\frac{1}{2}$ in. (38 mm.) between centers and located symmetrically in regard to the center line. Suitable mechanism shall be provided for raising and lowering the magazine. An opening shall be located in the left side of the box to permit the reading, by means of a mirror, of the color numbers stamped, as mirror images, on the side of the magazine. A pure white opal glass approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in. (82 by 44 by 1.75 mm.) shall be mounted across the illumination end of the box. The glass shall be ground or etched on the inner side to diffuse light rays. A vertical partition, approximately $\frac{1}{8}$ in. (3 mm.) in thickness, shall extend along the horizontal axis of the box from the opal glass to the transverse partition which contains the magazine. This partition divides the illumination end of the box into two compartments. In the top of the box, centrally-located over these two compartments, there shall be circular openings

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

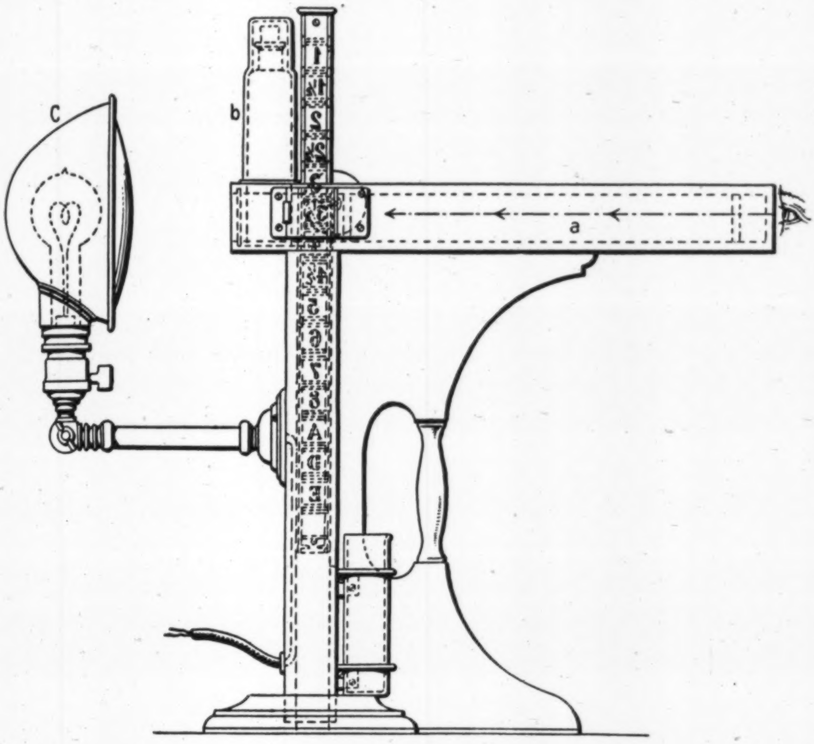
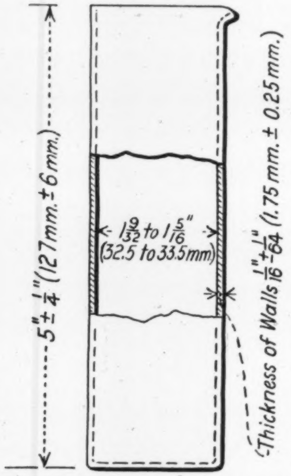


FIG. 1.—A.S.T.M. Union Colorimeter.

of such size as to accommodate the standard jar and 4-oz. sample bottles.

Color Standards. (*d*) The glass color standards shall be 12 in number as specified in Table I. These glasses shall be mounted in a magazine. The magazine shall have an additional opening containing no glass standard so that two bottles of petrolatum may be compared in the colorimeter. The width of the glass color standards shall be not less than $\frac{5}{8}$ in. (16 mm.).

Glass Test Jar. (*e*) The standard glass jar, Fig. 2, shall be a true cylinder of clear colorless glass. The internal diameter shall be not less than $1\frac{9}{32}$ in. (32.5 mm.) nor more than $1\frac{5}{16}$ in. (33.5 mm.). The thickness of the wall shall be $\frac{1}{16}$ in. ± $\frac{1}{64}$ in. (1.75 mm. ± 0.25 mm.). The height of the cylinder shall be 5 in. ± $\frac{1}{4}$ in. (127 mm. ± 6 mm.).



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Thickness of Walls 1/16" ± 1/64" (1.75 mm. ± 0.25 mm.)

FIG. 2.—Standard Glass Jar for Use with A.S.T.M. Union Colorimeter.

Light Shield. (*f*) The light shield, *b*, Fig. 1, shall be of any suitable material. It shall be dull black on the inside and of such size as to shield completely all light from the tops of the cylinders, or oil sample bottles, when they are in place in the colorimeter.

Artificial Daylight Lamp. (*g*) The artificial daylight lamp, *c*, Fig. 1, may for convenience be fastened to the base supporting the box. It shall consist of a 60-watt A-21 Mazda daylight lamp, fitting into a socket equipped with a parabolic metal reflector and mounted on a swivel. The inside of this reflector shall be brightly finished at all times with bright aluminum paint or brightly polished silver or nickel. In the front of the reflector shall be mounted a dished, but not lenticular, glass color screen of such composition and color as, in conjunction with the A-21 Mazda daylight lamp, will yield by spectrum analysis a light closely approximating Northern daylight. When in normal position, the color screen shall be 4 in. (102 mm.) from the white opal glass.

The artificial daylight lamp shall be used for referee work. In case electric current is not available, the colorimeter may be used by exposing the opal glass to Northern daylight with no colored objects in the immediate foreground.

PROCEDURE

Petrolatums not Darker than 8 Color.

3. Petrolatums not darker than 8 color, when examined, shall be heated to from 20 to 30° F. (11 to 17° C.) above the melting point. The petrolatum to be examined may be observed in the ordinary 4-oz. sample bottle, but in referee work a standard jar shall be used. The jar shall be placed in the right-hand compartment while in the other compartment shall be placed a 4-oz. sample bottle of distilled water. The jar and bottle shall be covered with the shield, and the artificial daylight lamp lighted. The color of the petrolatum is obtained by determining the glass color standard which most nearly matches the color of the petrolatum under examination. The colors of petrolatums which are intermediate to the standard colors may be expressed in terms of the darker standard as "lighter than" or "minus."

TABLE I.—GLASS COLOR STANDARDS OF A.S.T.M. UNION COLORIMETER.

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1½	No. 1½ N.P.A	Cream White	0.60	8.0	....
2	No. 2 N.P.A	Extra Pale	2.5	26.0	....
2½	No. 2½ N.P.A	Extra Lemon Pale	4.6	27.0	....
3	No. 3 N.P.A	Lemon Pale	6.9	32.0	....
3½	No. 3½ N.P.A	Extra Orange Pale	9.4	45.0	....
4	No. 4 N.P.A	Orange Pale	14.0	50.0	0.55
4½	No. 4½ N.P.A	Pale	21.0	56.0	0.55
5	No. 5 N.P.A	Light Red	35.0	93.0	....
6	No. 6 N.P.A	Dark Red	60.0	60.0	0.55
7	No. 7 N.P.A	Claret Red	60.0	106.0	1.8
8	No. 8 N.P.A	....	166.0	64.0	....

NOTE: *Example.*—When a petrolatum has a color between 7 and 8, the color may be expressed as "lighter than 8" or "8 minus."

The daylight lamp may be brought closer to the opal glass in determining the darker colors.

Petrolatums Darker than 8 Color.

4. Petrolatums darker than 8 color shall be diluted with kerosine. The color of the kerosine shall be not darker than +21 as determined in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (A.S.T.M. Designation: D 156 – 23 T) of the American Society for Testing Materials.[1] A mixture of exactly 15 per cent by volume of petrolatum, and 85 per cent by volume of kerosine shall be used in all cases. The kerosine shall be heated to a temperature 20 to 30° F. (11 to 17° C.) above the melting point of the petrolatum under examination before the mixture is made. The color of the mixture shall be obtained in accordance with the procedure described in Section 3.

The numbers designating the color of all petrolatums which have been diluted to make the determination, shall be followed by the designation "Dil."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 682 (1923); also 1932 Book of A.S.T.M. Tentative Standards, p. 557

TENTATIVE METHOD OF TEST
FOR
GRAVITY OF PETROLEUM AND PETROLEUM PRODUCTS BY MEANS OF THE HYDROMETER[1]

A.S.T.M. Designation: D 287 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1930, 1932.

Scope. 1. This method covers the determination of the specific gravity and the A.P.I. gravity of crude petroleum and petroleum products normally handled as liquids. The determination of the gravity of mixtures of petroleum products with other substances is treated as a special case owing to the fact that the coefficients of expansion of such mixtures may not be the same as those of petroleum or its products. The determination of the specific gravity of road oils, road tars, asphalt cements and soft tar pitches is covered by the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials[2] and the testing of these products is, therefore, specifically excluded from the scope of this method.

DEFINITIONS

Specific Gravity. 2. (*a*) *Specific Gravity.*—The specific gravity of a petroleum oil and of mixtures of petroleum products with other substances is the ratio of the weight of a given volume of the material at a temperature of 60° F. (15.56° C.) to the weight of an equal volume of distilled water at the same temperature, both weights being corrected for the buoyancy of air.

A. P. I. Gravity. (*b*) *A.P.I. Gravity.*—The A.P.I. gravity scale is an arbitrary one which is related to the specific gravity of a petroleum oil in accordance with the formula:

$$\text{Degrees A. P. I.} = \frac{141.5}{\text{sp. gr. } 60^\circ/60^\circ \text{ F.}} - 131.5$$

A table showing the equivalent specific gravity, pounds per gallon and gallons per pound at 60° F. for each degree A.P.I. from 0 to 100° A.P.I. is given in the Appendix to this method.

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[1] **Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.**

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 664.

APPARATUS

There are two kinds of hydrometers in common use, the plain type and the combined thermometer and hydrometer, known as a thermo-hydrometer. Although the thermo-hydrometer type of instrument is sufficiently satisfactory for routine use, the thermometer incorporated in it possesses certain inherent defects of design which render it unfit for use when results of unquestioned accuracy are desired. Therefore, in all referee tests the temperature of the sample being tested must be determined by means of a separate thermometer.

Hydrometer Calibrations.

3. *Hydrometer Calibrations.*—The hydrometer may be calibrated either in terms of specific gravity or degrees A.P.I. It shall be of glass of the conventional constant mass and variable displacement type, with a paper hand-written scale printed in black ink. The range may be any suitable portion of the interval between 0 and 100° A.P.I. (1.0760 to 0.6112 sp. gr.) and it shall be so divided that 0.1° A.P.I. or 0.0005 of a unit of specific gravity shall not be less than 1 mm. (0.039 in.) in width. The value of the smallest sub-divisions shall be 0.1° A.P.I. when the instrument is calibrated in degrees A.P.I. or 0.0005 of a unit of specific gravity when it is calibrated in the specific gravity scale. The accuracy of calibration of the hydrometer shall be such that the error at any point of the scale shall not exceed the value of one smallest scale division. Each fifth smallest subdivision on the scale shall be denoted by a longer line. The graduations shall be numbered at each multiple of 1° A.P.I. or at each multiple of 0.01 of a unit of specific gravity, in accordance with the type of calibration used. The paper scale, or an extension thereof, of the hydrometer shall have plainly printed on it the name of the manufacturer, a serial number and the definition of the scale. There shall be a mark on the stem of the hydrometer corresponding to a fixed mark on the paper scale, to provide a check against possible displacement of the scale.

NOTE.—In the case of A.P.I. hydrometers the scale is defined by the expression:

$$\text{"Degrees A.P.I.} = \frac{141.5}{\text{sp. gr. } 60°/60° \text{ F.}} - 131.5\text{"}$$

In the case of specific gravity hydrometers the inscription "Sp. gr. 60°/60° F., Petroleum" is sufficient to denote that the hydrometer is intended to determine specific gravities at 60° F. relative to water at 60° F. when the readings are taken at 60° F.

The long axis of the hydrometer shall assume a vertical position when the instrument is floating freely in the sample. Any solid material, such as shot, paper, etc., used in the weighting of the hydrometer shall be firmly secured in place by the use of a suitable cement, the softening point of which lies well above 215° F. When mercury is used for weighting, it shall be placed in a small bulb below the main bulb of the hydrometer and completely separated from the bulb by means of a glass partition.

Thermometers.

4. (*a*) *Separate Thermometer.*—These specifications cover a total immersion thermometer graduated in either Fahrenheit or Centigrade degrees as specified, the ranges being −5 to +215° F. or −20 to +102° C., respectively.

TYPE: Etched stem, glass.
LIQUID: Mercury.
RANGE AND SUBDIVISION: −5 to +215° F. in 0.5° F. or −20 to +102° C. in 0.2° C.
TOTAL LENGTH: 403 to 409 mm. (15.87 to 16.10 in.).
STEM: Plain front, enamel back, suitable thermometer tubing.
    Diameter 7 to 8 mm. (0.276 to 0.315 in.).
BULB: Corning normal or equally suitable thermometer glass, heavy wall.
    Length 14 to 19 mm. (0.55 to 0.75 in.).
    Diameter 6 to 7 mm. (0.236 to 0.275 in.).
DISTANCE TO −5° F. or −20° C. LINE FROM BOTTOM OF BULB: 32 to 51 mm. (1.26 to 2.00 in.).
DISTANCE TO +215° F. or +102° C. LINE FROM TOP OF THERMOMETER 25 to 45 mm. (0.98 to 1.77 in.)
FILLING ABOVE MERCURY: Nitrogen gas.
TOP FINISH: Glass ring.
GRADUATIONS: All lines, figures and letters clear cut and distinct. Each whole degree Fahrenheit or Centigrade line to be longer than the remaining lines. Graduations to be numbered at each multiple of 5° F. or 2° C.
IMMERSION: Total.
SPECIAL MARKING: "A.S.T.M. Gr.," a serial number and the manufacturer's name or trade mark shall be etched on the stem.
SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 0.25° F. or 0.1° C.
STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of from 30 to 40° F. or 15 to 20° C.
CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Gr. −5 to +215° F." or "A.S.T.M. Gr. −20 to +102° C." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

(*b*) *Thermometer for Thermo-hydrometer.*—The thermometer incorporated in the thermo-hydrometer type of instrument shall be of the paper scale type (scale to be placed in either the bulb or stem of the hydrometer) having a range of from 20 to 130° F. or 60 to 220° F.

depending upon the range of the hydrometer. The paper temperature scale shall be graduated in 2° F. divisions accurate to ± 1° F. (Note) and, when located in the stem of the hydrometer, shall be printed in red ink to avoid any possibility of its being confused with the black gravity scale.

NOTE.—This approximates the limit of accuracy which it is possible to obtain in this type of thermometer. It becomes at once obvious, therefore, in view of the following facts, that a high degree of accuracy in the determination of the gravity of an oil can not be expected when this type of thermometer is used for the determination of the temperature of the sample undergoing test.

Between 10 and 11° A.P.I., one degree A.P.I. is equivalent to 0.0070 of a unit of specific gravity. Between 90 and 91° A.P.I., one degree A.P.I. is equivalent to only 0.0028 of a unit of specific gravity. In correcting the observed gravity of an oil of 10° A.P.I. for temperature, an error of ±2° F. in the determination of the temperature of the oil will introduce maximum error of only 0.1° A.P.I. (0.0007 sp. gr.) in the gravity. In correcting the observed gravity of an oil of 90° A.P.I. for temperature, an error of 1° F. in the determination of the temperature of the oil will introduce a maximum error of 0.3° A.P.I. (0.00084 sp. gr.) in the gravity. For convenience, the following table is given which shows the errors at each tenth degree A.P.I. from 10 to 100° A.P.I. which may be introduced into a corrected gravity as the result of an error of ±1° F. in the determination of the observed temperature:

OBSERVED GRAVITY, DEG. A.P.I.	RESULTANT MAXIMUM ERROR IN CORRECTED GRAVITY, DEG. A. P. I. PER ± 1° F. ERROR IN OBSERVED TEMPERATURE
10–11	0.1
20–21	0.1
30–31	0.1
40–41	0.1
50–51	0.2
60–61	0.2
70–71	0.2
80–81	0.2
90–91	0.3
At 99	0.3

Hydrometer Cylinder.

5. *Hydrometer Cylinder.*—The hydrometer cylinder in which the sample for the gravity test is confined may be made of metal or clear glass and shall be cylindrical in shape. For convenience in pouring it may have a lip on the rim. The inside diameter of the cylinder shall be at least 2.54 cm. (1.0 in.) greater than the outside diameter of the hydrometer used in it. The height of the cylinder shall be such that the length of the column of sample it contains is greater by at least 2.54 cm. (1.0 in.) than the portion of the hydrometer which is immersed beneath the surface of the sample after a state of equilibrium has been reached.

PROCEDURE

Petroleum and Petroleum Products.

6. (*a*) The determination of the gravity of crude petroleum or its products may be made at any suitable temperature between 0 and 195° F. in accordance with the procedure described in Section 7. The observed gravity at the observed temperature shall be corrected to the gravity at 60° F. as described in Section 8.

Mixtures of Petroleum with Other Substances.

(*b*) The gravity of mixtures of petroleum products with other substances shall be determined at a temperature of 60° F. in accordance with the procedure described in Section 7, since there are no nationally recognized tables giving the coefficients of expansion of such mixtures.

Procedure.

7. The sample to be tested for gravity shall be poured into the clean hydrometer cylinder without splashing, so as to avoid the formation of air bubbles and to reduce to a minimum the evaporation of the lower boiling constituents of the lighter oils. If air bubbles are formed they shall be removed after they have collected on the surface, by touching them with a piece of clean blotting paper or filter paper before the hydrometer is placed in the sample. If the sample to be tested is easily volatile both the hydrometer and hydrometer cylinder shall be cooled before use to a temperature below that of the sample.

The cylinder containing the prepared sample shall be placed in a vertical position in a place free from air currents. The hydrometer shall be carefully lowered into the sample to a level two smallest scale divisions below that at which it will float and shall then be released. When the hydrometer has come to rest, floating freely away from the walls of the cylinder, the gravity shall be read as the point at which the surface of the sample apparently cuts the hydrometer scale. In the case of samples sufficiently transparent this point shall be determined by placing the eye slightly below the level of the liquid and slowly raising it until the surface of the sample first seen as a distorted ellipse seems to become a straight line cutting the hydrometer scale. In the case of non-transparent samples where this procedure cannot be followed, the point on the hydrometer scale to which the sample rises above the main surface of the liquid shall be read with the eye placed slightly above the plane of the surface of the sample. This reading shall then be corrected by subtracting in the case of A.P.I. hydrometers or adding in the case of specific-gravity hydrometers, an amount equal to the height which the sample rises on the hydrometer stem above the main liquid surface. This height will vary for different oils and different hydrometers and the amount of correction necessary will depend upon the width of the hydrometer scale graduations. The necessary correction factor shall be determined, therefore, for the particular hydrometer in use by observing the height above the main surface of the liquid to which the oil rises on the hydrometer scale when the hydrometer in question is immersed in a transparent oil having a surface tension similar to that of the sample under test.

NOTE.—In the routine testing of opaque crude petroleum with the usual type of hydrometer with a 12-deg. range, it is customary and permissible to correct the reading taken as prescribed above for non-transparent samples by an arbitrary deduction of 0.1° A.P.I. from the observed gravity reading.

The temperature of the sample shall be determined from the reading of the separate thermometer placed in the sample or from that of the thermometer contained in the hydrometer when the thermo-hydrometer type of instrument is used (see Note).

NOTE.—Precautions should, of course, be taken to prevent the temperature of the sample from changing appreciably during the time necessary to complete the test. This may be done when testing non-viscous oils by choosing a temperature of test only slightly different from the room temperature. When testing viscous oils which must be heated before testing it will be necessary to surround the test cylinder with a bath maintained at a constant desired temperature during the time of test.

Although it is usually satisfactory to determine the temperature of the sample immediately after reading the hydrometer, it is recommended that in all referee tests this temperature be determined both before and after the hydrometer is read.

CALCULATION

Calculation. 8. In the case of crude petroleum and petroleum products the determinations made in Section 7 are commonly referred to as "observed gravity and observed temperature." These observations shall be corrected to the gravity at 60° F. by the use of Tables 1 and 3 of the "National Standard Petroleum Oil Tables" as published in the U. S. Bureau of Standards *Circular No. 154*. Table 1 shall be employed if the observed gravity is in degrees A.P.I. and Table 3 if expressed as specific gravity.

Interpolations in Table 1 shall be made as follows: When the observed gravity ends in 1, 2, 3, 4 or 5 tenths of a degree A.P.I., find the degrees A.P.I. at 60° F. corresponding to the observed gravity, disregarding the tenths of a degree. To this value add tenths of a degree dropped from the observed gravity to obtain the corrected value of the gravity in degrees A.P.I. at 60° F. When the observed gravity ends in 6, 7, 8 or 9 tenths find the degrees A.P.I. at 60° F. corresponding to the next larger value of observed gravity in the table. Correct this figure by subtracting a number of tenths equal to the difference between the observed value and the next larger value.

ACCURACY

Duplicate Determinations.

9. Duplicate determinations shall agree within 0.1° A.P.I. or the equivalent thereof in units of specific gravity at the particular gravity being determined when the same hydrometer and thermometer are used in the tests.

Separate laboratories using different hydrometers and thermometers should obtain duplicate results agreeing within 0.5° A.P.I. or the equivalent thereof in units of specific gravity at the particular gravity being determined. When extreme accuracy is desired instruments certified by the U. S. Bureau of Standards shall be used, and the necessary corrections made.

APPENDIX

The following table is primarily an abridgement of Table 5 of the "National Standard Petroleum Oil Tables" as published in the U. S. Bureau of Standards *Circular No. 154,* which contains similar data for each 0.1° A.P.I. from 10 to 100° A.P.I., inclusive. The data for gravities from 0 to 9° A.P.I., inclusive, have been added in order to extend the use of the A.P.I. gravity scale to petroleum oils having a specific gravity slightly greater than unity.

TABLE SHOWING SPECIFIC GRAVITIES, POUNDS PER GALLON, AND GALLONS PER POUND AT 60° F., CORRESPONDING TO DEGREES A.P.I.

Degrees A. P. I.	Specific Gravity at 60°/60° F.	Pounds per Gallon at 60° F.[1]	Gallons per Pound at 60° F.[1]	Degrees A. P. I.	Specific Gravity at 60°/60° F.	Pounds per Gallon at 60° F.[1]	Gallons per Pound at 60° F.[1]
0	1.0760	8.962	0.1116	50	0.7796	6.490	0.1541
1	1.0679	8.895	0.1124	51	0.7753	6.455	0.1549
2	1.0599	8.828	0.1133	52	0.7711	6.420	0.1558
3	1.0520	8.762	0.1141	53	0.7669	6.385	0.1566
4	1.0443	8.698	0.1150	54	0.7628	6.350	0.1575
5	1.0366	8.634	0.1158	55	0.7587	6.316	0.1583
6	1.0291	8.571	0.1167	56	0.7547	6.283	0.1592
7	1.0217	8.509	0.1175	57	0.7507	6.249	0.1600
8	1.0143	8.448	0.1184	58	0.7467	6.216	0.1609
9	1.0071	8.388	0.1192	59	0.7428	6.184	0.1617
10	1.0000	8.328	0.1201	60	0.7389	6.151	0.1626
11	0.9930	8.270	0.1209	61	0.7351	6.119	0.1634
12	0.9861	8.212	0.1218	62	0.7313	6.087	0.1643
13	0.9792	8.155	0.1226	63	0.7275	6.056	0.1651
14	0.9725	8.099	0.1235	64	0.7238	6.025	0.1660
15	0.9659	8.044	0.1243	65	0.7201	5.994	0.1668
16	0.9593	7.989	0.1252	66	0.7165	5.964	0.1677
17	0.9529	7.935	0.1260	67	0.7128	5.934	0.1685
18	0.9465	7.882	0.1269	68	0.7093	5.904	0.1694
19	0.9402	7.830	0.1277	69	0.7057	5.874	0.1702
20	0.9340	7.778	0.1286	70	0.7022	5.845	0.1711
21	0.9279	7.727	0.1294	71	0.6988	5.817	0.1719
22	0.9218	7.676	0.1303	72	0.6953	5.788	0.1728
23	0.9159	7.627	0.1311	73	0.6919	5.759	0.1736
24	0.9100	7.578	0.1320	74	0.6886	5.731	0.1745
25	0.9042	7.529	0.1328	75	0.6852	5.703	0.1753
26	0.8984	7.481	0.1337	76	0.6819	5.676	0.1762
27	0.8927	7.434	0.1345	77	0.6787	5.649	0.1770
28	0.8871	7.387	0.1354	78	0.6754	5.622	0.1779
29	0.8816	7.341	0.1362	79	0.6722	5.595	0.1787
30	0.8762	7.296	0.1371	80	0.6690	5.568	0.1796
31	0.8708	7.251	0.1379	81	0.6659	5.542	0.1804
32	0.8654	7.206	0.1388	82	0.6628	5.516	0.1813
33	0.8602	7.163	0.1396	83	0.6597	5.491	0.1821
34	0.8550	7.119	0.1405	84	0.6566	5.465	0.1830
35	0.8498	7.076	0.1413	85	0.6536	5.440	0.1838
36	0.8448	7.034	0.1422	86	0.6506	5.415	0.1847
37	0.8398	6.993	0.1430	87	0.6476	5.390	0.1855
38	0.8348	6.951	0.1439	88	0.6446	5.365	0.1864
39	0.8299	6.910	0.1447	89	0.6417	5.341	0.1872
40	0.8251	6.870	0.1456	90	0.6388	5.316	0.1881
41	0.8203	6.830	0.1464	91	0.6360	5.293	0.1889
42	0.8155	6.790	0.1473	92	0.6331	5.269	0.1898
43	0.8109	6.752	0.1481	93	0.6303	5.246	0.1906
44	0.8063	6.713	0.1490	94	0.6275	5.222	0.1915
45	0.8017	6.675	0.1498	95	0.6247	5.199	0.1924
46	0.7972	6.637	0.1507	96	0.6220	5.176	0.1932
47	0.7927	6.600	0.1515	97	0.6193	5.154	0.1940
48	0.7883	6.563	0.1524	98	0.6166	5.131	0.1949
49	0.7839	6.526	0.1532	99	0.6139	5.109	0.1957
				100	0.6112	5.086	0.1966

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[1] The data in this column are based upon apparent weights in air, the weight of one gallon of water at 60° F. in air being assumed to be 8.32828 lb. Consequently, a correction for the buoyancy of air is required in computing these figures from the specific gravities in the second column.

TENTATIVE METHOD OF TEST
FOR
VAPOR PRESSURE OF NATURAL GASOLINE (REID METHOD)[1]

A.S.T.M. Designation: D 323 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1930; REVISED, 1931, 1932.

Scope. 1. This method is intended for the determination of the vapor pressure of natural gasoline.

APPARATUS

Vapor-Pressure Bomb. 2. The vapor-pressure bomb consisting of two sections or chambers, an upper section or air chamber and a lower section or gasoline chamber, shall conform to the following requirements:

(*a*) *Air Chamber.*—The upper section or air chamber, shall be a cylindrical vessel 2 to $2\frac{1}{8}$ in. in diameter and 10 in. ± $\frac{1}{8}$ in. in length, inside dimensions. In one end of the air chamber a $\frac{1}{4}$-in. pipe thread shall be tapped, to receive the gage coupling, shown in Fig. 1. Other means of connecting the air chamber with the pressure gage may be employed, provided the requirements of Paragraphs (*d*) and (*e*) are fulfilled. In the other end of the air chamber an opening approximately $\frac{1}{2}$ in. in diameter shall be provided for purposes of coupling with the gasoline bomb. The nature of this opening will depend upon the method of coupling employed. The air chamber must drain completely from either end when held in a vertical position and for this reason the ends may be slightly convex.

(*b*) *Gasoline Chamber for Sampling Materials at Atmospheric Pressure.*—The lower section or gasoline chamber, shown in Fig. 1 (*a*), shall be a cylindrical vessel of the same inside diameter as the air chamber and $2\frac{1}{2}$ in. ± $\frac{1}{16}$ in. in inside length. In one end of the gasoline chamber an opening approximately $\frac{1}{2}$ in. in diameter shall be provided for purposes of coupling with the air chamber. The nature of this opening will depend upon the method of coupling employed. The other end of the gasoline chamber shall be completely closed. The gasoline chamber must drain completely when inverted and for this reason the top may be slightly convex.

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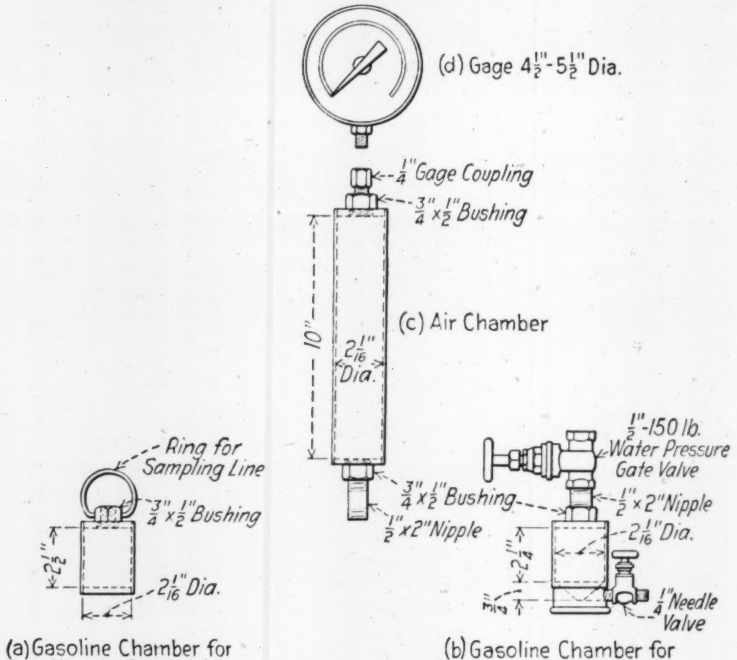
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

This method is essentially the same as that contained in the Interstate Commerce Commission Regulations for the Transportation of Explosives and Other Dangerous Articles by Freight and Express and in Baggage Service.

(*c*) *Gasoline Chamber for Sampling Materials Under Pressure.*—For testing natural gasoline where it is impracticable to obtain a sample by immersing the gasoline chamber in the liquid, as for example, gasoline in pressure storage or gasoline being transported by pipe line,


(d) Gage 4½"-5½" Dia.
¼" Gage Coupling
¾" x ½" Bushing
(c) Air Chamber
10"
2 1/16" Dia.
Ring for Sampling Line
¾" x ½" Bushing
2½"
2 1/16" Dia.
½"-150 lb. Water Pressure Gate Valve
¾" x ½" Bushing
½" x 2" Nipple
½" x 2" Nipple
2 1/16" Dia.
2¼"
¾"
¼" Needle Valve

(a) Gasoline Chamber for Sampling by Immersion

(b) Gasoline Chamber for Sampling Under Pressure

FIG. 1.—Vapor Pressure Bomb, Screw Coupling Type.

a ¼-in. needle valve shall be attached near the bottom of the gasoline chamber and a ½-in. gate valve shall be introduced in the coupling between the chambers as illustrated in Fig. 1 (*b*). The vertical dimensions of the gasoline chamber proper in Fig. 1 (*b*) are such that the assembly fulfills the requirements of Paragraph (*e*) for the type of construction illustrated.

(*d*) *Method of Coupling Air and Gasoline Chambers.*—Any method of coupling the air and gasoline chambers may be employed, for example, a simple thread, a union, or a clamp. The sole provision in this respect is that the assembly shall be free from leaks under the conditions of test. Responsibility for freedom from leaks rests with the user.

(*e*) *Volumetric Capacity of Air and Gasoline Chambers.*—The ratio of the volume of the air chamber to the volume of the gasoline chamber shall be between the limits of 3.8 and 4.2. To determine the volume of the air chamber, insert a $\frac{1}{4}$-in. plug in the gage coupling, invert the chamber, fill with water up to and including the portion of the coupling device attached permanently to the air chamber and then carefully measure the volume of water. To determine the volume of the gasoline chamber fill with water up to and including the portion of the coupling device attached permanently to the gasoline chamber, and then carefully measure the volume of water.

Pressure Gage.

3. The pressure gage shall be a standard Bourdon type spring gage $4\frac{1}{2}$ to $5\frac{1}{2}$ in. in diameter. The range of the gage used shall be governed by the vapor pressure of the sample being tested, as follows: For those samples with a vapor pressure not in excess of 12 lb. per sq. in. absolute at 100° F. the gage shall have a 15-lb. scale. For those samples whose vapor pressures are between 12 and 45 lb. per sq. in. absolute at 100° F., the upper limit of the scale of the gage shall not be less than 45 nor more than 60 lb. Gages shall be checked frequently and adjusted if found in error.

Water Bath.

4. The water bath shall be of such dimensions that the vapor-pressure bomb may be immersed to the bottom of the pressure gage. Means for maintaining the bath at a constant temperature of 100° F ± 0.5° F. should be provided.

Connections.

5. (*a*) All permanent connections may be made tight by soldering or tinning.

(*b*) Special threads or other suitable means may be used in making the connection between the two chambers in order to obtain a tight connection without the use of a wrench.

PROCEDURE

Filling the Gasoline Chamber.

6. (*a*) *Sampling Tank Cars and Open Tanks.*—The empty gasoline chamber, Fig. 1 (*a*), shall first be immersed in the tank or container of the liquid to be tested and allowed to fill while being raised and lowered through the liquid. This first filling is for the purpose of thoroughly washing the chamber, which should then be emptied. The chamber shall then be refilled in the same manner, care being exercised to see that it is completely filled with the liquid.

(*b*) *Sampling Systems Under Pressure.*—The gasoline chamber equipped with valves, top and bottom, Fig. 1(*b*), shall be used.

Before drawing the sample, the liquid section of the gasoline chamber shall be cooled to a temperature as low as or lower than that of the gasoline to be tested. The sample shall be taken as follows:

Close both valves and connect the gasoline chamber to the tank, pipe line, or other receptacle holding the liquid to be tested, by means of the lower valve of the chamber. The sample must be taken at a place which will ensure that a representative sample of the gasoline is being obtained.

With the upper valve closed, open the valve on the tank or pipe line and then open the lower valve on the gasoline chamber, allowing full tank or line pressure to be exerted on the chamber. Open slightly the upper valve of the chamber and allow gasoline to escape until a volume equal to at least twice the capacity of the gasoline chamber shall have been displaced. This procedure insures the removal of all air from the chamber. The operation of purging should be accomplished without allowing the pressure in the chamber to drop below that of the tank or line. After filling the gasoline chamber, close both top and bottom valves in the order mentioned, and disconnect the chamber from the tank or pipe line. After disconnecting the gasoline chamber, attach it to the air chamber immediately; and immediately open the upper valve of the gasoline chamber. If the air chamber is not immediately attached, the gasoline chamber should be kept chilled to prevent rupturing due to expansion of its contents.

TABLE I.—TEMPERATURES TO WHICH GASOLINE AND GASOLINE CHAMBER SHALL BE COOLED BEFORE POURING SAMPLE.

APPROXIMATE VAPOR PRESSURE OF SAMPLE, LB.	TEMPERATURE OF SAMPLE AND CHAMBER WHEN POURING, DEG. FAHR. ± 5° F.
9 (or under)	50
12	40
16	30
20	25
25	20
30	15

(*c*) *Sampling by Pouring.*—A sample shall not be transferred to the gasoline chamber by pouring unless it is impossible to obtain it by either of the methods described in Paragraphs (*a*) and (*b*). When this is the case both the liquid and the gasoline chamber shall be cold enough so that no appreciable change in composition of the sample occurs during the pouring. Table I gives the maximum pouring temperatures for gasolines of various vapor pressures. The responsibility for errors incurred by pouring rests solely with the operator. Pouring shall not be used in referee tests.

(*d*) *Sampling by Water Displacement.*—It is recommended that transfer by water displacement be used when the methods described in Paragraphs (*a*), (*b*) and (*c*) cannot be employed.

Procedure.

7. Prior to each test the air chamber, from which the gage has been removed, shall be thoroughly purged of any gasoline vapors that may remain from a previous test. The purging may best be accomplished by filling the air chamber with warm water (90 to 100° F.) and allowing it to drain. This operation shall be repeated at least five times. If the air chamber is purged some time before the test is made, it should be rinsed with water (temperature optional) just before the test is started. Prior to each test, the gage should be shaken to dislodge gasoline that may remain from a previous test. The gage shall then be attached to the air chamber.

The temperature of the air and water vapor in the air chamber shall be determined by inserting a thermometer of suitable range and accuracy inside the chamber just before making the connection with the gasoline chamber. The thermometer shall be allowed to remain in the air chamber for not less than 5 minutes before the temperature is read. This temperature reading shall be recorded as the "initial air temperature." It is necessary that the initial air temperature shall be the actual temperature of the air in the air chamber when attached to the gasoline chamber. Immediately, after determining the initial air temperature, the air chamber with gage in place shall be attached tightly to the gasoline chamber containing the sample to be tested (see Section 6). If a threaded coupling is employed, a little shellac or other suitable sealing material on the threads may assist in making a tight connection.

The vapor-pressure bomb shall then be turned upside down and shaken vigorously in this position. This operation should be repeated several times. The bomb shall then be immersed at least up to the bottom of the pressure gage in the water bath, which shall be held at a constant temperature of 100° F. ± 0.5° F. While the bomb is immersed in the bath, the apparatus shall be closely observed for leaks. The coupling device is normally in the liquid section of the apparatus and because it is most in use, shall be given particular attention. Liquid leaks are more difficult to detect than vapor leaks. If a leak is detected the test shall be discarded. After 5 minutes the bomb shall be withdrawn from the bath, inverted, shaken vigorously and replaced in the bath. Thereafter, at intervals of two minutes, the bomb shall be withdrawn from the bath, inverted, shaken vigorously and replaced in the bath. These operations shall be done quickly to avoid cooling the bomb and its contents.

Prior to each removal of the bomb from the bath, the gage reading shall be observed. The gage should be tapped lightly prior to each reading. The temperature of the bath shall also be closely observed to make certain that it is within the specified limits. When consecutive gage readings thus observed become constant the value of the reading shall be recorded as the "uncorrected vapor pressure" of the sample under test.

TABLE II.—CORRECTIONS TO CONVERT UNCORRECTED VAPOR PRESSURES TO REID VAPOR PRESSURES.

INITIAL AIR TEMPERATURE,[a] DEG. FAHR.	CORRECTIONS IN POUNDS PER SQUARE INCH FOR VARIOUS TEMPERATURES AS CALCULATED FOR NORMAL BAROMETRIC PRESSURES OF:				
	760 MM.	745 MM.	700 MM.	650 MM.	600 MM.
32	−2.9	−2.9	−2.7	−2.6	−2.5
40	−2.6	−2.6	−2.4	−2.3	−2.2
50	−2.2	−2.2	−2.1	−2.0	−1.9
60	−1.8	−1.8	−1.7	−1.6	−1.6
70	−1.4	−1.4	−1.3	−1.3	−1.2
80	−1.0	−1.0	−1.0	−0.9	−0.9
90	−0.5	−0.5	−0.5	−0.5	−0.5
100	0	0	0	0	0
110	+0.6	+0.6	+0.5	+0.5	+0.5

$$\text{Correction Factor} = \frac{(P_a - P_t)(t - 100)}{460 + t} - (P_{100} - P_t)$$

where t = the air chamber temperature at beginning of test, deg. Fahr.

P_t = the vapor pressure of water, lb. per sq. in., at t° F.

P_{100} = the vapor pressure of water, lb. per sq. in., at 100° F.

P_a = normal barometic pressure in lb. per sq. in. at place where test is conducted.

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[a] For intermediate air temperatures, the corrections should be interpolated to the nearest 0.1 lb. per sq. in.

Calculations. 8. To calculate the "Reid vapor pressure" of the sample under test, the "uncorrected vapor pressure" must be corrected for the change in the pressure of the water vapor and air in the air chamber due to the differences between the "initial air temperature" and the temperature of the bath. Table II shows the corrections to apply for "initial air temperatures" ranging from 32° F. to 110° F. This corrected value shall be recorded as the "Reid vapor pressure."

NOTE.—*Example:* If the initial air temperature is 82° F. and the uncorrected vapor pressure is 24.6 lb., the Reid vapor pressure is 24. 6 lb. minus 0.9 lb. or 23.7 lb.

Due to the fact that the atmospheric pressure provided in the air chamber counteracts the external atmospheric pressure, the only pressure acting internally on the pressure gage is the absolute vapor pressure of the liquid in the bomb so that the gage reading is the absolute vapor pressure of the liquid in pounds per square inch at 100° F. For purposes of brevity the "Reid vapor pressure" shall be recorded in pounds, without reference to temperature used in the test or to unit of surface.

9. With proper care and attention to detail, duplicate results obtained for Reid vapor pressure values should not differ from each other by more than 0.5 lb. **Accuracy.**

TENTATIVE STANDARD
VISCOSITY-TEMPERATURE CHART FOR LIQUID PETROLEUM PRODUCTS[1]

A.S.T.M. Designation: D 341 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. The viscosity-temperature chart, of which Fig. 1 is a facsimile, is a convenient means for ascertaining the viscosity of a petroleum oil[3] at any temperature, within a limited range, provided viscosities at two temperatures are known. Conversely, the chart may be used to ascertain the temperature at which a desired viscosity is attained.

Precaution. 2. The chart should be used only in that temperature range in which the petroleum oil is a liquid. A safe range is that between initial boiling point and cloud point.

Description 3. The chart, $21\frac{1}{2}$ by $16\frac{1}{4}$ in., covers a temperature range from –30° F. to 450° F. and a Saybolt Universal viscosity range from 37 seconds to 100,000,000 seconds. The chart is so constructed that for any given petroleum oil the viscosity-temperature points lie on a straight line.

Procedure. 4. Plot the two known viscosity-temperature points[4] on the chart. With great care draw accurately a sharply defined, straight line through them. A point on this line, within the range defined in Section 2, shows the viscosity at the corresponding desired temperature, and *vice versa.*

Extrapolation. 5. Viscosity-temperature points on the extrapolated portion of the line, but still within the range defined in Section 2, are satisfactory provided the viscosity-temperature line is located quite accurately. For purpose of extrapolation it is especially important that the two known viscosity-temperature points be far apart. If these two viscosity-temperature points are not sufficiently far apart, experimental errors in the viscosity determinations and in drawing the line

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[1] Criticisms of this Tentative Standard are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

[2] Accepted for publication as tentative by Committee E-10 on Standards, March 8, 1932.

[3] While the chart is based on the behavior of petroleum products, information as to its applicability to other liquids is earnestly solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

[4] If Saybolt viscosities are not known they should be determined in accordance with the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part II, p. 550.

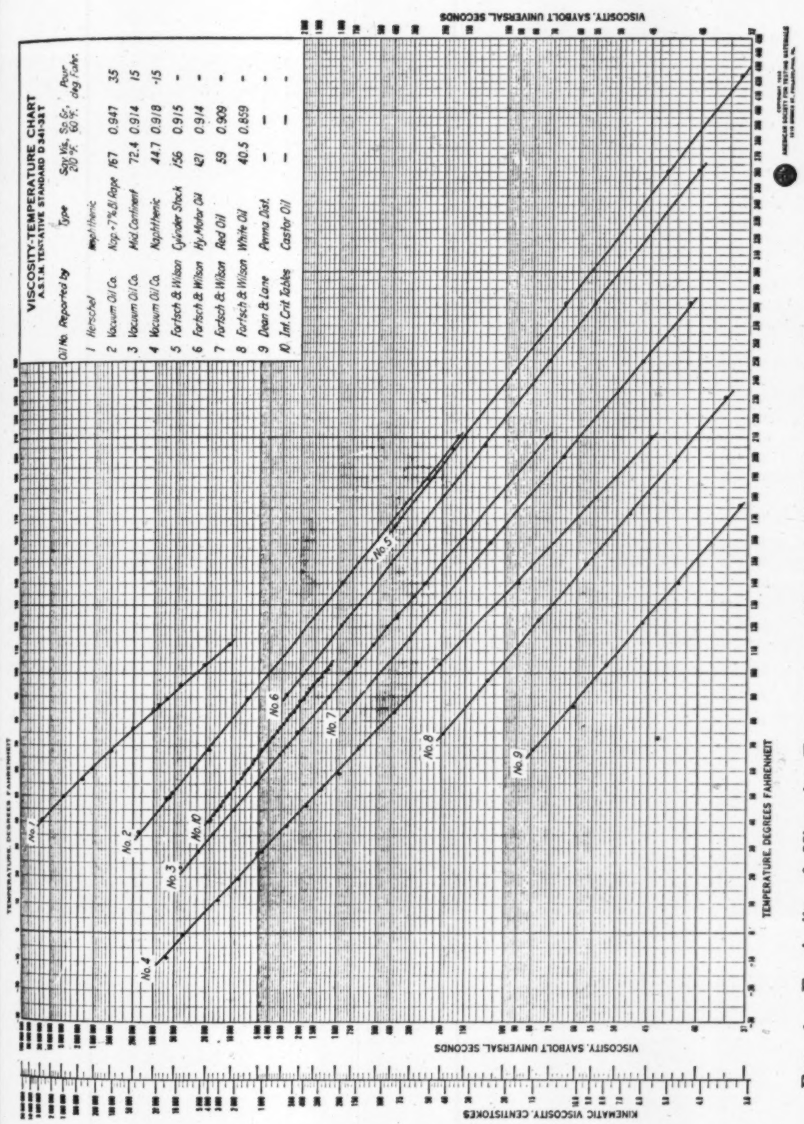

FIG. 1.—Facsimile of Viscosity-Temperature Chart on Which Several Typical Experimental Curves Have Been Plotted (Chart Size: 16¾ by 21½ in.).

Full-size Copies of Viscosity-Temperature Chart are available at following prices: Single copy, 25 cents; pad of 25 copies, $1.50; four pads, $5.00

American Society for Testing Materials
1315 Spruce St., Philadelphia, Pa.

may seriously affect the accuracy of extrapolated points, particularly if the difference between an extrapolated temperature and the nearest temperature of determination is greater than the difference between the two temperatures of determination. In extreme cases a viscosity determination at a third temperature is advisable.

Kinematic Viscosity.

6. A kinematic viscosity scale parallels the Saybolt Universal scale. Kinematic viscosity is absolute viscosity divided by the density of the liquid at the temperature of viscosity measurement. The unit of kinematic viscosity is the *stoke* corresponding to the *poise* which is the unit of absolute viscosity. The relations are shown in the following equations where d represents density and t Saybolt Universal seconds, both at the temperature of viscosity measurement:

$$\text{Kinematic viscosity (in centistokes)} = \frac{\text{Absolute viscosity (in centipoises)}}{d}$$

When t is 100 or less:

$$\text{Kinematic viscosity (in centistokes)} = 0.226\, t - \frac{195}{t}$$

When t is over 100:

$$\text{Kinematic viscosity (in centistokes)} = 0.220\, t - \frac{135}{t}$$

APPENDIX

In addition to its primary purpose, this viscosity-temperature chart furnishes a convenient means for estimating the viscosity at a given temperature of blends of petroleum liquids, provided viscosities of the component liquids at the given temperature are known. For this purpose the 0° F. line may be assumed to represent 100 per cent of the light component and the 100° F. line to represent 100 per cent of the heavy component. Plot the known viscosities of the two components on the proper lines at points corresponding to the values on the viscosity scale, and draw a straight line through them. Points on this line show viscosities at the given temperature of blends of the particular components, depending upon the proportion of the light and heavy component.

> *Example.*—As an example, estimate the viscosity of a blend of 15 per cent of an oil having a viscosity of 38 seconds, Saybolt Universal at 100° F. and 85 per cent of an oil having a viscosity of 153 seconds, Saybolt Universal at 100° F. Draw a straight line between the 38 seconds Saybolt point on the 0° F. line and the 153 seconds Saybolt point on the 100° F. line. The printed figures between 0 and 100° F. represent the percentage of the heavy component. The line crosses the 85° line at a value corresponding to 105 seconds. Thus the estimated viscosity of the blend is 105 seconds, Saybolt Universal at 100° F. The experimental value was 108 seconds.

NOTE.—In case one of the components is motor gasoline, plot the gasoline point on the extension of the 0° F. line 6 in. below its intersection with the 37 seconds Saybolt Universal viscosity line and plot the point corresponding to the heavy component on the 100° F. line. Points on the straight line drawn between these two points show viscosities of blends of motor gasoline and oil at the same temperature as the components.

TENTATIVE METHOD OF TEST
FOR
CONSISTENCY OF PORTLAND-CEMENT CONCRETE[1]

A.S.T.M. Designation: D 138 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1925, 1926, 1932.

Scope. 1. This test covers the method to be used both in the laboratory and in the field for determining consistency of concrete.[2]

Apparatus. 2. The test specimen shall be formed in a mold of No. 16 gage galvanized metal in the form of the lateral surface of the frustrum of a cone with the base 8 in. in diameter, the upper surface 4 in. in diameter, and the altitude 12 in. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mold shall be provided with foot pieces and handles as shown in Fig. 1.

Sample. 3. When the test is made at the mixer, the sample shall be taken from the pile of concrete immediately after the entire batch has been discharged. When testing concrete that has been hauled from a central mixing plant, the sample shall be taken from the concrete immediately after it has been dumped on the subgrade.

Procedure. 4. The mold shall be filled in three layers, each approximately one-third the volume of the mold. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mold as the concrete slides from it, in order to insure symmetrical distribution of concrete within the mold. Each layer shall be rodded with 25 strokes of a $\frac{5}{8}$-in. rod, 24 in. in length, bullet pointed at the lower end. The strokes shall be distributed in a uniform manner over the cross-section of the mold and shall penetrate into the underlying layer.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

This method is in effect a revision of the former Tentative Specifications for Workability of Concrete for Concrete Pavements (A.S.T.M. Designation: D 62 - 20 T) which were accordingly withdrawn in 1922.

[2] This test is not considered applicable when there is a considerable amount of coarse aggregate over 2 in. in size in the concrete. The committee is now working on a method suitable for determining the consistency of concrete using aggregate over 2 in. in size.

The bottom layer shall be rodded throughout its depth. After the top layer has been rodded the surface of the concrete shall be struck off with a trowel so that the mold is exactly filled. The mold shall be immediately removed from the concrete by raising it carefully in a vertical direction. The slump shall then be measured immediately by determining the difference between the height of the mold and the height at the vertical axis of the specimen.

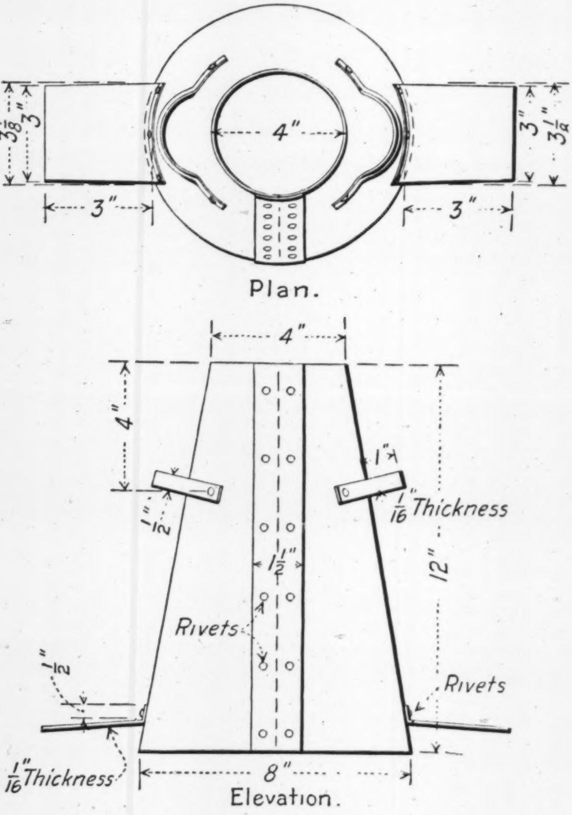
3 1/8"
3"
4"
3"
3"
3 1/2"
3"
Plan.
4"
4"
1"
1/16" Thickness
1/2"
1 1/2"
12"
Rivets
Rivets
1/2"
1/16" Thickness
8"
Elevation.

FIG. 1.—Mold for Consistency Test.

Slump. 5. The consistency shall be recorded in terms of inches of subsidence of the specimen during the test, which shall be known as the slump.

$$\text{Slump} = 12 - \text{inches of height after subsidence}$$

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF CALCIUM CHLORIDE[1]

A.S.T.M. Designation: D 345 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

DETERMINATION OF TOTAL CALCIUM

1. Weigh accurately a sample of approximately 5 g. (see Note 1) and dissolve in water. Add sufficient HCl to clear, and then make up to a volume of 500 cc. Pipette a 25.00 ml. aliquot and add enough dilute NH_4OH to make slightly alkaline. Methyl orange or red may be used as indicator. Add 20 ml. of cold, saturated NH_4Cl solution and dilute to from 100 to 125 ml. Heat to boiling and while stirring to precipitate the calcium add 20 ml. of cold saturated $(NH_4)_2C_2O_4$. Let stand one minute and if the precipitate does not show a tendency to settle well, bring back to boiling and continue the stirring. Let settle 20 minutes and filter through No. 42, 11-cm. Whatman filters or paper of an equivalent grade. Wash free from oxalate and chloride with hot water. Wash the precipitate back into the original beaker and dilute to about 100 ml. Dissolve the precipitate with 10 to 15 ml. of 0.25 *N* H_2SO_4, heat to about 80° C. and titrate to a pink color with 0.1 *N* KMnO4. Add the paper and finish the titration to a faint pink with the standard KMnO4.

$$\text{Percentage of } CaCl_2 = \frac{\text{milliliters of 0.1 } N \text{ } KMnO_4 \times 11.1}{\text{weight of sample in grams}}$$

The calculated percentage of $CaCl_2$ shall be corrected for $Ca(OH)_2$ and $CaCO_3$.

DETERMINATION OF TOTAL ALKALINITY AND MAGNESIUM COMPOUNDS

2. Weigh accurately a 10.00-g. sample (see Note 1), place in a 400-ml. beaker and dissolve in 25 ml. of water. Add a drop of phenolphthalein indicator and titrate with 0.1 *N* HCl till the brilliant pink color fades or becomes a dull, slowly-returning color when tested by adding another drop or two of indicator. Then add enough of the

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

0.1 N HCl in excess to give a permanent red color after the addition of a drop of methyl orange indicator. Titrate back to the neutral point with 0.1 N NaOH and adjust to a faint pink color with 0.1 N HCl. Use these solutions for the subsequent determination of magnesium compounds.

The net volume of acid used is sometimes calculated as calcium hydroxide for convenience, as follows:

$$\text{Percentage of } Ca(OH)_2 = \text{milliliters of } 0.1\ N\ HCl \times 0.0037 \times 10$$

To the neutral solutions add 9 ml. of normal NaOH solution which will precipitate $Mg(OH)_2$ along with some $Ca(OH)_2$. Filter the precipitate and transfer as much as possible to the filter. Now dissolve the precipitate from the paper to the original beaker with about 10 ml. of HCl(1:1). Add 30 ml. of cold, saturated NH_4Cl solution. With a volume of about 150 ml., heat to boiling and add from 50 to 60 ml. (or an excess) of cold saturated $(NH_4)_2C_2O_4$ solution. Heat just to boiling while stirring, and slowly make alkaline with dilute NH_4OH. Let stand 10 to 15 minutes and filter through a retentive qualitative paper such as Whatman's No. 2 or 3. Save this filtrate. Return the precipitate to the original beaker, dissolve in HCl (1:1) as before, add 15 ml. of cold saturated NH_4Cl solution and 10 ml. of the $(NH_4)_2C_2O_4$ solution, heat to boiling and slowly make alkaline with dilute NH_4OH. When the precipitate is well formed and settles readily, filter as before, and combine the two perfectly clear filtrates. Concentrate to about a 250-ml. volume. If much magnesium is present, the oxalate may precipitate. Add HCl to dissolve it. At a temperature of approximately 70° C., slowly add 10 ml. of $(NH_4)_2HPO_4$ solution (15-percent). Add concentrated NH_4OH slowly until the precipitate is formed, then add excess. Let stand over night, stirring vigorously several times and also just before filtering. Filter through a Gooch crucible or a No. 42 Whatman paper, or paper of equivalent quality and wash with cold NH_4OH (1:10). Ignite to constant weight and weigh as $Mg_2P_2O_7$. If the alkalinity is appreciable and the total magnesium low, this should be calculated as $Mg(OH)_2$. Any balance of magnesium over total alkalinity would be $MgCl_2$.

$$\text{Percentage of } Mg(OH)_2 = \text{grams of } Mg_2P_2O_7 \times 0.524 \times 10$$
$$\text{Percentage of } Mg(OH)_2 \times 34.3 = \text{milliliters of } 0.1\ N\ HCl \text{ due to } Mg(OH)_2$$

If the alkalinity titration with phenolphthalein was stopped and the milliliters recorded with the brilliant pink faded, the milliliters represent actual calcium hydroxide present.

$$\text{Percentage of } Ca(OH)_2 = \text{milliliters of } 0.1\ N\ HCl \times 0.0037 \times 10$$

The difference (MeO − Ph) minus cubic centimeters due to $Mg(OH)_2$ equals the milliliters due to $CaCo_3$.

Percentage of $CaCO_3$ = milliliters of 0.1 *N* HCl due to $CaCO_3 \times 0.0050 \times 10$
Percentage as $CaCl_2$ = (milliliters for $Ca(OH)_2$ + milliliters for $CaCO_3$) $\times$ 0.00555×10

Deduct this latter percentage from total calcium as net $CaCl_2$.

NOTE.—If a large amount of $MgCl_2$ (2 or 3 per cent) is present the calculation of $CaCO_3$ will be inaccurate.

TOTAL ALKALI CHLORIDES AS SODIUM CHLORIDE

3. The chlorides KCl and NaCl shall be determined together. Where it is desired to distinguish between them, the potassium may be determined by any standard method and the two reported separately. The perchlorate method may be used for this determination. For routine work the KCl and NaCl shall be reported as percentage of NaCl. The method used shall be as follows:

Dissolve an 8.000-g. sample (see Note 1) in 50 ml. of hot water, add 1 g. of c.p. $Ca(OH)_2$, mix well and boil gently for a minute. Dilute to exactly 100 ml. in a volumetric flask. Filter through a dry paper, discarding the first 10 ml., pipette a 25.00-ml. aliquot, add 20 ml. of water; heat to boiling and add 50 ml. of hot $(NH_4)_2C_2O_4$ (5-per-cent) or $(NH_4)_2CO_3$ (4-per-cent) preferably the latter. Make up to volume and mix well. Let stand till temperature is about that of the room and adjust the volume. Finally, filter through a dry retentive filter paper. Add a few milliliters of $(NH_4)_2C_2O_4$, heat to boiling, and filter. If the filtrate is not clear, refilter, discarding the first 10 ml. Pipette 25.00-ml. aliquot in 250-ml. beakers and add 1 ml. of concentrated HCl. Evaporate to dryness on a steam bath. Thoroughly ignite in a muffle or heat-treating furnace (see Note 2) at a temperature of from 300 to 350° C. In about 30 minutes, organic and ammonium salts should have been driven off. Cool, dissolve in 10 ml. of water, add 3 drops of Na_2CrO_4 or K_2CrO_4 (5-per-cent) solution as indicator, and titrate with 0.02 *N* $AgNO_3$ (see Note 3) to a pink end point. If the ignition was correctly done, there will be but little brown or yellow coloration due to charred organic residue to interfere with seeing the end point. Run a blank on the reagents used. If this is less than 0.5 ml. neglect it, if over 0.5 ml. subtract from the titration after deducting 0.5 ml. (1.00 ml. of 0.02 *N* $AgNO_3$ is equivalent to 0.00117 g. NaCl). In the method as given, 0.5000 g. of sample is finally titrated.

Percentage of NaCl = milliliters 0.02 *N* $AgNO_3 \times 0.00117 \times 1.05 \times 100 \div 0.5000$
or
Percentage of NaCl = milliliters 0.02 *N* $AgNO_3 \times 0.246$.

RAPID TECHNICAL METHOD

4. For ordinary purposes, where the quantity of material purchased does not warrant the employment of the foregoing method of analysis, calcium chloride is deemed as satisfactory if the total chlorides present determined by titration with 0.1 *N* $AgNO_3$ and calculated to $CaCl_2$ is in excess of 78 per cent and if not more than a slight precipitate of $Mg(OH)_2$ appears when a 10-per-cent filtered solution of the material is made alkaline with $NH_4(OH)_2$.

No material shall be rejected under this technical method of analysis and in case the calcium chloride does not come up to the standards given it shall be analyzed by the methods described in Sections 2 and 3, inclusive.

EXPLANATORY NOTES

NOTE 1.—Instead of weighing out separate samples as indicated in Sections 1, 2, and 3, a 25-g. sample may be diluted to a volume of 100 ml., and 1 ml. of this solution used for the procedure in Section 1, 40 ml. for the procedure in Section 2, and 32 ml. for the procedure in Section 3. The 1 ml. should be measured with a standard calibrated pipette, and the 40 ml. and 32 ml. with a burette. These volumes shall then be further diluted to conform to the concentrations indicated under Sections 1, 2, and 3. This handling will render accurate distribution of the insoluble $Mg(OH)_2$ and $CaCO_3$ present more difficult than using direct weighed samples.

Instead of weighing accurately a 10.00-g. sample, a sample of approximately 10 g. may be used if desired, in which case the percentage of $Ca(OH)_2$ may be calculated as follows:

$$\text{Percentage of Ca (OH)}_2 = \frac{\text{milliliters of 0.1 } N \text{ HCl} \times 0.0037 \times 100}{\text{weight of sample in grams}}$$

NOTE 2.—In case a muffle or furnace with close heat control is not available, a moderate bunsen flame played over the beaker may be used to volatilize the ammonium and organic compounds. In this case it would be advisable to control the determination by means of a known mixture having NaCl present in the same magnitude.

NOTE 3.—The 0.02 *N* $AgNO_3$ may be conveniently made by diluting 50.00 ml. of exactly 0.1 *N* solution to a 250-ml. volume. There is an empirical correction to be made on the factor which amounts to the 0.02 *N* value multiplied by about 1.05. This can be determined exactly by running on known mixtures having the same magnitude composition as the calcium chloride to be analyzed.

TENTATIVE METHOD OF TEST
FOR
DUCTILITY OF BITUMINOUS MATERIALS[1]

A.S.T.M. Designation: D 113 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1926, 1932.[2]

Ductility. 1. The ductility of a bituminous material is measured by the distance to which it will elongate before breaking when two ends of a briquet of the material of the form described in Section 2, are pulled apart at a specified speed and at a specified temperature. Unless otherwise specified, the test shall be made at a temperature of 25° C. ±0.5° C. (77° F. ± 0.9° F.) and with a speed of 5 cm. per minute (± 5.0 per cent).

APPARATUS

Mold. 2. The mold shall be similar in design to that shown in Fig. 1. Dimensions shown in Fig. 1 shall be as given with the permissible variations indicated. The mold shall be made of brass, the ends, *b* and *b′*, being known as clips, and the parts, *a* and *a′*, as sides of the mold. The dimensions of the mold shall be such that, when properly assembled, it will form a briquet having the following dimensions:

Total length	7.45 to 7.55 cm.
Distance between clips	2.97 to 3.06 cm.
Width at mouth of clip	1.98 to 2.02 cm.
Width at minimum cross-section (halfway between clips)	0.99 to 1.01 cm.
Thickness throughout	0.99 to 1.01 cm.

Water Bath. 3. The water bath shall be maintained at the specified test temperature varying not more than 0.1° C. (0.18° F.) from this temperature. The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. and shall be supported on a perforated shelf not less than 5 cm. from the bottom of the bath.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

[2] Latest revision accepted by Committee E-10 on Standards, August 11, 1932.

Testing Machine. 4. For pulling the briquet of bituminous material apart, any apparatus may be used that is so constructed that the briquet will be continuously immersed in water as specified in Section 7, while the two clips are pulled apart at a uniform speed, as specified, without undue vibration.

PROCEDURE

Melting and Molding. 5. The bituminous material to be tested shall be completely melted until thoroughly fluid by heating it in an oil bath maintained at the minimum temperature needed to properly liquefy the sample (Note). It shall then be strained through a No. 50 sieve and, after a thorough stirring, poured into the mold. The mold shall be assembled on a brass plate and, so as to prevent the material under test from sticking, the surface of the plate and interior surfaces of the sides *aa'*, Fig. 1, of the mold shall be thoroughly amalgamated. The plate upon which the mold is placed shall be perfectly flat and level so that the bottom surface of the mold will touch it throughout. In filling the mold, care shall be taken not to disarrange the parts and thus distort the briquet. In filling, the material shall be poured in a thin stream back and forth from end to end of the mold until it is more than level full. It shall be left to cool to room temperature and then placed in the water bath maintained at the specified temperature of test for 30 minutes, after which the excess bitumen shall be cut off by means of a hot straight-edged putty knife or spatula so that the mold shall be just level full.

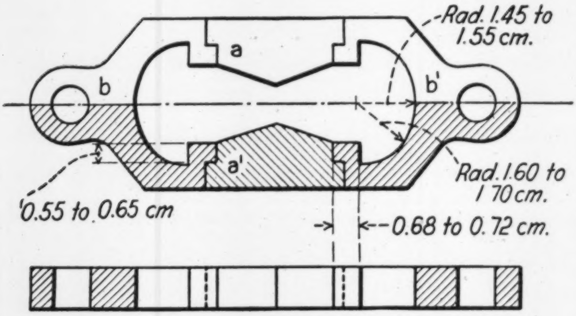

FIG. 1.—Mold for Ductility Test Specimens.

NOTE.—When paving asphalt cements are being tested, the oil bath shall be maintained at a temperature of from 125 to 150° C. (257 to 302° F.).

Keeping at Standard Temperature. 6. The brass plate and mold, with briquet, shall then be placed in the water bath and kept at the specified temperature for at least $1\frac{1}{2}$ hours, when the briquet shall be removed from the plate, the side pieces detached, and the briquet immediately tested.

7. The rings at each end of the clips shall be attached to the pins or hooks in the ductility machine and the two clips pulled apart at a uniform speed as specified until the briquet ruptures. A variation of ±5 per cent from the speed specified will be allowed. The distance through which the clips have been pulled to produce rupture shall then be measured in centimeters. While the test is being made, the water in the tank of the ductility machine shall cover the sample both above and below it by at least 2.5 cm. and shall be kept continuously at the temperature specified within ±0.5° C. (±0.9° F.). **Testing.**

REPORT

8. (*a*) A normal test is one in which the material between the two clips pulls out to a point or thread until rupture occurs at the point where the thread has practically no cross-sectional area. The average of three normal tests shall be taken and reported as the ductility of the sample. **Report.**

(*b*) If the bituminous material comes in contact with the surface of the water or the bottom of the bath, the test shall not be considered normal.

NOTE.—When the specific gravity of the bituminous material to be tested is below 0.98 or above 1.01, the specific gravity of the water bath in the ductility machine shall be made the same as the material to be tested by the addition of either methyl alcohol or sodium chloride.

(*c*) If a normal test is not obtainable on three successive tests, the ductility shall be reported as being unobtainable under the conditions of the test.

TENTATIVE METHOD OF TEST
FOR
RESIDUE OF SPECIFIED PENETRATION[1]

A.S.T.M. Designation: D 243 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1928, 1932.[2]

Scope. 1. This method of test covers the determination of percentage of residue having a specified penetration at 100 g., 5 seconds, 25° C. (77° F.), obtained by heating a road oil or a semi-solid asphalt having a penetration of more than 100, at a temperature of 249 to 260° C. (480 to 500° F.). When the penetration of the residue is not otherwise stated it shall be understood to be 100. The residue obtained is available for tests as desired.

APPARATUS

Apparatus. 2. The apparatus shall consist of a container, heating bath, hot plate, and thermometer, with necessary accessory apparatus.

Container. 3. The container in which the sample is to be tested shall be a flat-bottom, cylindrical seamless tin box, 70 mm. ($2\frac{3}{4}$ in.) in diameter and 45 mm. ($1\frac{3}{4}$ in.) in depth.

NOTE.—The American Can Co.'s 6-oz. gill style flat-bottom, seamless ointment box, deep pattern, fulfills these requirements.

Heating Bath. 4. (*a*) The heating bath shall be a cast-iron air-bath permitting the immersion of the container to a depth of $1\frac{1}{4}$ in. through an opening $\frac{1}{16}$ in. larger in diameter than the container. It shall support the container $\frac{1}{4}$ in. above the hot plate and with at least $\frac{1}{4}$ in. free air space between the sides of the container and of the air-bath below the opening. A suitable air-bath is shown in Fig. 1.

Hot Plate. (*b*) The air-bath shall be heated upon a suitably mounted hot plate, heated either electrically or by means of a gas flame. The plate shall be capable of maintaining the sample continuously at the required temperature, and apparatus necessary to fulfill this requirement, such as a rheostat or gas pressure regulator, shall be provided.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

[2] Latest revision accepted by Committee E-10 on Standards, August 11, 1932.

Thermometer. 5. The thermometer shall conform to the following requirements.[1] These specifications cover a special thermometer graduated to either Centigrade or Fahrenheit degrees as specified, the ranges being −6 to +400° C., or +20 to +760° F., respectively.

Type: Etched stem, glass.

Liquid: Mercury.

Range and Subdivision: −6 to +400° C. in 2° C. or +20 to +760° F. in 5° F.

Total Length: 303 to 307 mm. (11.92 to 12.08 in.).

Stem: Plain front, enamel back, suitable thermometer tubing.
Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

Bulb: Corning normal or equally suitable thermometric glass.
Length, not over 13 mm. (0.51 in.).
Diameter, not greater than stem.

Distance to −6° C. or 20° F. Line from Bottom of Bulb: 40 to 50 mm. (1.57 to 1.97 in.)

Distance to 400° C. or 760° F. Line from Top of Thermometer: 30 to 45 mm (1.18 to 1.77 in.).

Filling Above Mercury: Nitrogen gas.

Top Finish: Red glass ring.

Graduation: All lines, figures, and letters clear cut and distinct. The first and each succeeding 10° F. line to be longer than the intermediate lines. Graduations to be numbered at each multiple of 20°.

Immersion: 25 mm. or one inch. The words "1-in. immersion" on Fahrenheit thermometers or "25-mm. immersion" on Centigrade thermometers and a line around the stem 25.4 mm. or 1.00 in. above the bottom of the bulb shall be etched on the thermometer.

Special Marking: "A.S.T.M. Open Flash" a serial number and the manufacturer's name or trade mark shall be etched on the stem.

Scale Error: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 1° C. up to 372° C. or 2.5° F. up to 700° F.

Standardization: The thermometer shall be standardized at the ice point and at intervals of approximately 100° F. for 25-mm. or 1-in immersion and for the following temperatures of the emergent mercury column:

Thermometer Reading		Average Temperature of Emergent Mercury Column	
100° C.	200° F.	44° C.	110° F.
150° C.	300° F.	54° C.	129° F.
200° C.	400° F.	64° C.	150° F.
250° C.	500° F.	77° C.	175° F.
300° C.	600° F.	91° C.	205° F.
350° C.	700° F.	108° C.	240° F.

Test for Permanency of Range: After being subjected to a temperature between 360 to 370° C. or 680 to 700° F. for 24 hours, the accuracy shall be within the limit specified.

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[1] These specifications are the same as for the open cup flash point thermometer specified in the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92), 1930 Book of A.S.T.M. Standards, Part II, p. 517.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Open Flash, -6 to +400° C." or "A.S.T.M. Open Flash, +20 to +760° F.," according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

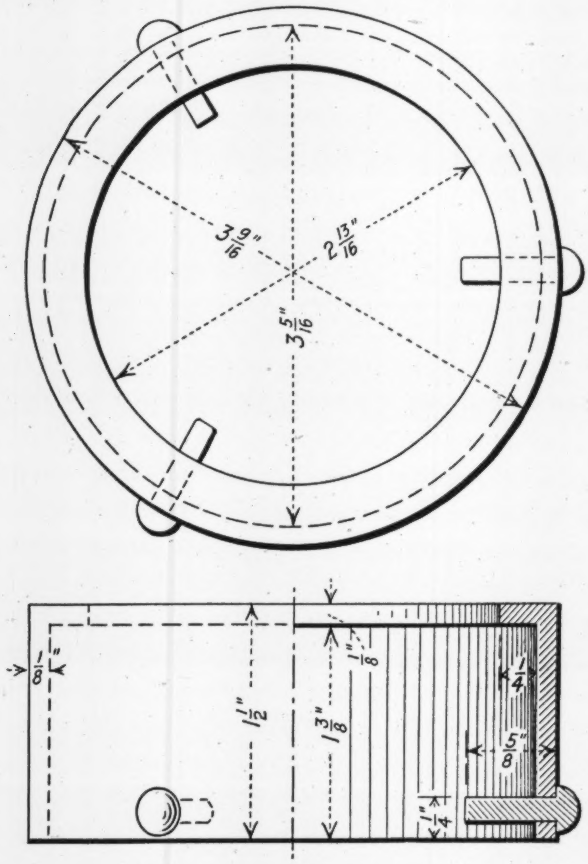

FIG. 1.—Cast-Iron Air-Bath.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

PREPARATION OF SAMPLE

Preparation of Sample. 6. The sample as received shall be thoroughly stirred and agitated, to insure a complete mixture before the portion for testing is removed.

PROCEDURE

Procedure. 7. One hundred grams (100.00 ± 0.10 g.) of the material to be tested shall be weighed into a tared container, which shall then be placed in the air-bath in position to be heated. The thermometer shall be supported in the sample equi-distant from the sides of the container and with the bottom of the bulb neither more than ¼ in. above nor touching the bottom of the container. The bulb shall be completely immersed in the sample throughout the heating. An assembly of the apparatus is shown in Fig. 2.

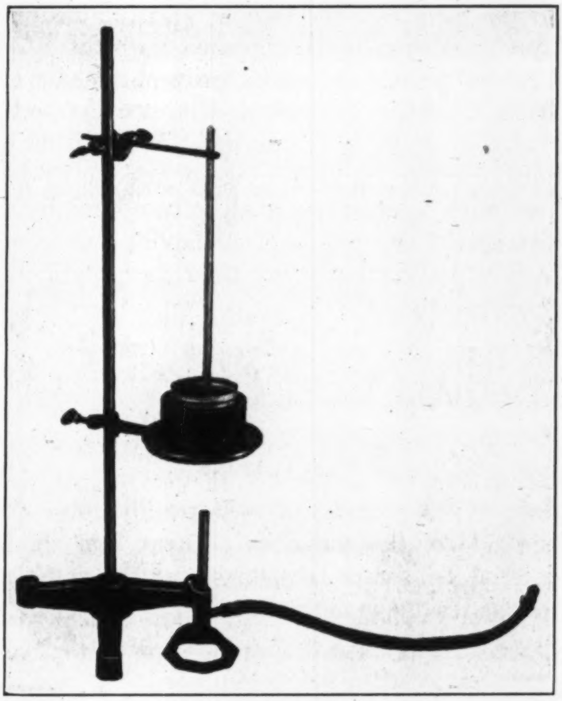

FIG. 2.—Assembly of Apparatus.

Heating. 8. The sample should be heated as rapidly as possible, to prevent foaming, to a temperature of 249° C. (480° F.) and during the evaporation, the temperature shall be maintained between 249° C. (480° F.) and 260° C. (500° F.). The sample shall be stirred with the thermometer from time to time to prevent local overheating and, to maintain a homogeneous sample, all cakes of hardened bitumen which form at the sides of the container shall be fluxed in the sample.

An experienced operator can judge approximately what percentage of residue he should obtain to secure the desired penetration.

When it is supposed that the residue will show the required penetration, the bitumen on the thermometer which may be readily scraped off shall be returned to the container, which then shall be removed from the air-bath, cooled and weighed. The penetration of the residue shall then be determined in accordance with the Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5) of the American Society for Testing Materials.[1]

9. It frequently is necessary to make several trials before a residue of the required penetration is obtained. If it is determined to be greater than that required, all water shall be removed from the container and the surface of the sample, and the heating and determination of penetration may be repeated as before. Ordinarily a residue shall be considered as satisfactorily obtained when its penetration is within 15 of that desired, and its percentage by weight of the original sample shall be calculated. When it is necessary to determine more precisely the percentage of residue having the specified penetration, such a percentage shall be computed by interpolation between percentages of two residues, one having a penetration greater and one having a penetration lower than that specified. The percentage shall be reported as:

Percentage of residue of .... penetration (determined ....) stating, first, the specified penetration, and second, the penetration actually determined for the sample tested or calculated by interpolation.

PRECAUTIONS

Precautions. 10. Certain types of road oil will readily form rings of hard asphalt at the side of the container. Great care should be taken that this material be completely fluxed in the sample before the penetration of the residue is determined.

ACCURACY

Accuracy. 11. Duplicate determinations should not differ by more than 1.0 per cent with the same operator nor more than 2.5 per cent between different laboratories.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 647.

TENTATIVE METHOD OF SAMPLING COKE FOR ANALYSIS[1]

A.S.T.M. Designation: D 346 - 32 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1932.

It is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the standard procedure described herein, for if the sampling is improperly done, the sample will be in error, and it may be impossible or impracticable to take another sample; whereas if an analysis is in error, another analysis can readily be made of the original sample.

Gross samples of not less than the quantities designated herein must be taken whether the coke to be sampled consists of a few tons or several hundred tons in order to minimize the effect of the chance inclusion or exclusion of too many or too few pieces of non-representative material.

For All Determinations Except Total Moisture

Time of Sampling.

1. (*a*) The coke shall be sampled preferably while it is being loaded into or unloaded from railroad cars, ships, barges, or trucks, or when discharged from supply bins, railroad cars, grab buckets, or other coke-conveying equipment.

(*b*) Samples collected from the surface of coke in piles, bins, cars, ships, or barges may be unreliable. When it is necessary to collect such samples, the following points should be kept in mind:

(*1*) *For run-of-oven coke and coke 2 in. and larger in size containing breeze*, samples collected from the surface of loaded shipments usually are unreliable because of segregation.

(*2*) *For shipments of coke which are loaded in layers from bottom to top over the entire area*, as in the case of barges, samples collected from the surface of loaded shipments are unreliable, because they may not be representative of the coke below the surface.

(*3*) *For shipments of coke free of breeze*, which are loaded from end to end by filling completely as the loading progresses from one end to the other, so that the coke on top should be similar to the coke below the surface, as in the case of open-top railroad cars, samples collected from the surface of loaded shipments should be fairly representative.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

In case it is necessary to collect a sample from coke exposed in bins or cars, nine equal increments shall be taken about 1 ft. below the surface. The nine sampling points shall be located as shown in Fig. 1.

Size of Increments.

2. To collect samples, a shovel or specially designed tool or mechanical means shall be used for taking equal portions or increments. For coke smaller than about 2 in., increments as small as 2 lb. may be taken, but for coke larger than about 2 in., increments shall be at least 5 lb.

Collection of Gross Sample.

3. The increments shall be regularly and systematically collected, so that the entire quantity of coke sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount will be collected. The standard gross sample shall be not less than the quantities given in the following table:

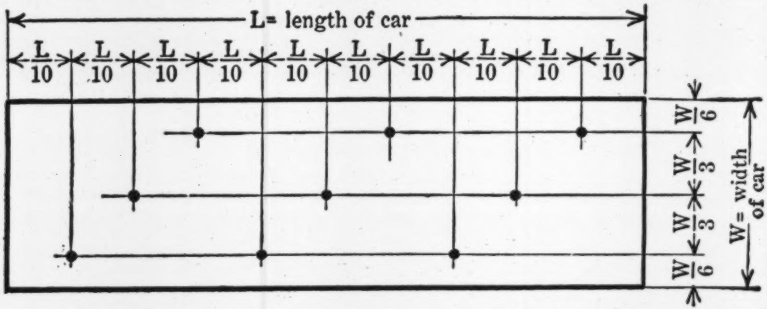

FIG. 1.—Location of Sampling Points from Exposed Surface of Car.

MINIMUM WEIGHTS OF GROSS SAMPLES OF COKE

Run-of-oven, Blast-furnace, Foundry, Water-gas, and any coke containing a range of size of pieces made from uncrushed or coarsely crushed coal (more than 10 per cent on ¼-in. square-hole sieve) except coke breeze	500 lb.[a]
Run-of-oven, Blast-furnace, Foundry, Water-gas and any coke containing a range of size of pieces made from crushed coal (not less than 90 per cent passing through a ¼-in. square-hole sieve) except coke breeze	250 lb.[a]
Closely-sized coke free of coke breeze	125 lb.
Coke breeze (all passing a ½- or ¾-in. square-hole sieve)	125 lb.

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[a] In case the pulverization of the coal is not known, take quantities designated for coke made from uncrushed or coarsely crushed coal.

Quantity Represented.

4. The unit from which a gross sample is taken shall not exceed 250 tons. Each lot of coke arising from a different source or known to be of different quality or size shall be sampled separately.

Crushing.

5. The entire gross sample shall be crushed, mixed, and reduced in quantity to convenient size for transmission to the laboratory. The sample shall be crushed preferably by means of jaw or roll

crushers, or in case mechanical crushing means are not available, the coke sample shall be crushed on a chilled-iron or hard-steel plate by impact of a tamper, hard bar or sledge, avoiding all rubbing action, as otherwise the ash content may be materially increased by the addition of iron from the sampling apparatus, even though hardened iron or steel is used. The crushing shall be done under such conditions as shall prevent loss of coke or accidental admixture of foreign matter. Samples of the quantities indicated in Table I shall be crushed so that no pieces of coke and impurities will be greater in dimension, as judged by eye, than specified for the sample before division into two approximately equal parts.

TABLE I.—WEIGHTS OF COKE SAMPLES WITH CORRESPONDING CRUSHING SIZES.

WEIGHT OF SAMPLE TO BE DIVIDED, LB.	LARGEST SIZE OF COKE AND IMPURITIES ALLOWABLE IN SAMPLE BEFORE DIVISION
250 or over	1 in.
125	¾ in.
60	½ in.
30	¼ in.

The method of reducing by hand the quantity of coke in a gross sample shall be carried out as described in Section 6, even should the initial size of coke and impurities be less than indicated in Table I.

Mixing and Reduction.

6. The progressive reduction in the weight of the sample to the quantities indicated in Table I shall be done by the following methods which are described and illustrated in Plate V of the Standard Method of Sampling Coal (A.S.T.M. Designation: D 21) of the American Society for Testing Materials.[1]

(*a*) The alternate-shovel method of reducing the gross sample shall be repeated until the sample is reduced to approximately 125 lb., and care shall be observed before each reduction in quantity that the sample has been crushed to the fineness specified in Table I.

The crushed coke shall be shoveled into a conical pile (Fig. 2 or 7, Plate V)[1] by depositing each shovelful of coke on top of the preceding one, and then formed into a long pile in the following manner: The sampler shall take a shovelful of coke from the conical pile and spread it out in a straight line (Fig. 3*A* or 8*A*) having a width equal to the width of the shovel and a length of 5 to 10 ft. The next shovelful shall be spread directly over the top of the first shovelful, but in the opposite direction, and so on back and forth, the pile being occasionally flattened, until all the coke has been formed into one long pile (Fig. 3*B* or 8*B*). The sampler shall then discard half of this pile, proceeding as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 684.

Beginning on one side of the pile, at either end, and shoveling from the bottom of the pile, the sampler shall take one shovelful (shovelful No. 1, Fig. 4 or 9) and set it aside; advancing along the side of the pile a distance equal to the width of the shovel, he shall take a second shovelful (shovelful No. 2) and discard it; again advancing in the same direction one shovel width, he shall take a third shovelful (shovelful No. 3) and add it to the first. The fourth (shovelful No. 4) shall be taken in a like manner and discarded, the fifth (shovelful No. 5) retained, and so on, the sampler advancing always in the same direction around the pile so that its size will be gradually reduced in a uniform manner. When the pile is removed, about half of the original quantity of coke should be contained in the new pile formed by the alternate shovelsful which have been retained. (Fig. 5*A* or 10*A* show the retained halves, and Fig. 5*B* or 10*B* the rejected halves.)

(*b*) After the gross sample has been reduced by the alternate-shovel method to approximately 125 lb., further reduction in quantity shall be by the quartering method. Before each quartering, the sample shall be crushed to the fineness specified in Table I.

Quantities of 60 to 125 lb. shall be mixed thoroughly by coning and reconing (Figs. 12 and 13); quantities less than 60 lb. shall be placed on a suitable cloth, measuring about 6 by 8 ft., mixed by raising first one end of the cloth and then the other (Fig. 18, 24 or 30), so as to roll the coke back and forth, and after being mixed thoroughly shall be formed into a conical pile by gathering together the four corners of the cloth (Fig. 19, 25 or 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed down vertically with a shovel, so that after the pile has been quartered, each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (Fig. 14, 20, 26 or 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (*BB* in Fig. 16, 22, 28 or 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coke remaining shall be crushed, mixed, coned, and quartered successively until tbe sample is reduced to approximately 30-lb.

(*c*) The 30-lb. quantity shall be crushed to $\frac{1}{4}$-in. size, mixed, coned, flattened and quartered. The laboratory samples shall include all of one of the quarters, or all of the two opposite quarters, as may be required. The laboratory sample shall be placed immediately in a suitable container and sealed in such a manner as to preclude tampering.

Reduction by Mechanical Means.

7. Only such riffles or other mechanical means as will give equally representative samples shall be used in substitution for the hand method of reduction in quantity herein standardized.

FOR THE DETERMINATION OF TOTAL MOISTURE

Sample for Total Moisture.

8. For determining total moisture, a special moisture sample weighing approximately 50 lb. shall be taken, except in the case of coke breeze, in which case the moisture sample shall weigh approximately 25 lb. The moisture sample shall be taken when the coke is being loaded or unloaded as the case may be, and shall be accumulated by placing in a waterproof receptacle with a tight-fitting lid small equal parts of the freshly-taken increments of the standard gross sample described in Section 2. The special moisture sample, without any preliminary crushing, shall preferably be dried to constant weight at a temperature of not less than 104 nor more than 200° C.[1] In case it is impracticable to dry the entire sample, the following procedures may be used:

For Coke Appearing Dry.—The special moisture sample shall be crushed rapidly to $\frac{1}{2}$-in size and reduced mechanically or by hand to about a 5-lb. quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory without delay.

For Coke Appearing Wet.—The special moisture sample shall be spread on tared pans, weighed, and air-dried or dried in a warm place or on a warm or heated surface until the coke appears dry, and weighed again. The sampling shall be completed as described in the preceding paragraph for coke appearing dry. This loss in weight divided by weight of sample, multiplied by 100, is the percentage of air-drying loss and should be corrected as follows for the moisture found in the sample sent to the laboratory:

$$\begin{array}{c}\text{Percentage}\\ \text{total moisture}\\ \text{(as received)}\end{array} = \frac{100 - \text{percentage of air-drying loss}}{100} \times \begin{array}{c}\text{percentage}\\ \text{moisture in air-}\\ \text{dried sample}\end{array} + \begin{array}{c}\text{percentage}\\ \text{of air-dry-}\\ \text{ing loss.}\end{array}$$

REPORT

Report.

9. Since in the report of the analysis, a brief description should be given of the method of taking the sample, by such characteristic expressions as "Belt Sample," "Top-of-car," etc., information as to how the sample is taken shall be included in the description which accompanies the sample sent to the laboratory.

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[1] Experiments made at the U. S. Bureau of Mines have shown that results checking within 0.5 per cent are obtained between these temperature limits. See A. C. Fieldner and W. A. Selvig, "The Determination of Moisture in Coke," U. S. Bureau of Mines *Technical Paper No. 148* (1917).

TENTATIVE METHOD OF SAMPLING COAL BY BALL-MILL METHOD[1]

A.S.T.M. Designation: D 271 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Ball-mill Method for Coal Appearing Wet or Dry:

(*a*) This method of sampling[2] does not require a total moisture sample of the coal passing an 840-micron (No. 20) sieve as do methods *A* and *B*.[3] The coal is first air-dried to bring it to a condition of approximate equilibrium with the air to minimize moisture change during the preparation of the sample for analysis. After air-drying all operations are performed with the utmost dispatch to prevent moisture change. Fine grinding of the sample is done in an air-tight ball mill. Total moisture is computed from the air-drying loss and the residual moisture in the sample prepared for analysis.

(*b*) Spread the sample on tared pans, weigh, and air-dry in the special moisture oven shown in Fig. 1,[3] at 10 to 15° C. above room temperature until the loss in weight between two successive weighings, made 6 to 12 hours apart, does not exceed 0.1 per cent per hour. Record the loss in weight as "air-drying loss."

(*c*) Immediately after the last weighing, quickly crush the entire sample by means of a roll-crusher adjusted so the product will pass an 840-micron (No. 20) sieve. Then, without sieving, quickly reduce the coal on the small riffle sampler to about 200 g. Put this 200-g. portion at once in the porcelain jar (1-gal. capacity) of an Abbé ball mill, sealed air-tight by means of a rubber gasket, and grind to pass a 250-micron (No. 60) sieve. The jar shall be slightly more than half full of well-rounded flint pebbles, about $\frac{3}{4}$ in. in diameter, and rotated at 60 to 75 r.p.m. Bituminous coals require from 10 to

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

This ball-mill method of sampling coal is intended to be added as an optional method of sampling coal in addition to the methods now standard and will be incorporated, when adopted as standard, as a new Section 5 in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30), see 1930 Book of A.S.T.M. Standards, Part II, p. 689.

[2] This method of sampling is used by the U. S. Bureau of Mines, see F. M. Stanton, A. C. Fieldner and W. A. Selvig, "Methods of Analyzing Coal and Coke," U. S. Bureau of Mines *Technical Paper No. 8*, p. 2 (1929).

[3] See Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 689.

20 minutes and anthracite about 1 hour of rotation to be pulverized to the designated fineness.

(*d*) When pulverization is complete, pour the contents of the jar on a $\frac{1}{2}$-in. square-mesh sieve, and separate the sample from the pebbles by shaking the sieve over a rubber mixing-cloth. Brush carefully the pebbles and inside of the jar to remove any adhering pulverized coal. A convenient size of sieve is one approximately 17 in. square. Then quickly pass the sample through a 250-micron (No. 60) sieve. To minimize moisture change, keep the sieve covered while the sample is being sieved. Usually some coarse particles, amounting to 0.2 to 0.4 per cent of the sample, remain on the sieve. As these particles are likely to consist largely of ash-forming substances, reduce them on a chromium-steel bucking board to pass the sieve and then add to what passed through the sieve. Quickly mix the sample on a rubber mixing-cloth and reduce to about 50 g. by passing through the small riffle sampler. Put this 50-g. portion which constitutes the laboratory sample, in a rubber-stoppered, wide-mouth, 4-oz. bottle. To minimize moisture change, the mixing and reducing of the pulverized sample after removal from the ball mill shall be done with utmost dispatch. The total time elapsing from the opening of the porcelain jar to the stoppering of the laboratory sample shall not exceed 3 minutes.

Calculation.—As all the analytical determinations are made on the air-dried sample passing a 250-micron (No. 60) sieve, calculate the analysis to "as-received" and "dry-coal" bases from the analysis of the air-dried coal in the following manner:

Calculation from analysis of "air-dried" coal to coal "as received." All figures expressed in per cent.

$$\text{Moisture ``as received''} = \text{moisture} \times \frac{(100 - \text{air-drying loss})}{100} + \text{air-drying loss.}$$

$$\text{Volatile matter ``as received''} = \text{volatile matter} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Fixed carbon ``as received''} = \text{fixed carbon} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Ash ``as received''} = \text{ash} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Sulfur ``as received''} = \text{sulfur} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Hydrogen ``as received''} = \text{hydrogen} \times \frac{(100 - \text{air-drying loss})}{100} + \tfrac{1}{9}\ \text{air-drying loss.}$$

$$\text{Carbon ``as received''} = \text{carbon} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Nitrogen "as received"} = \text{nitrogen} \times \frac{(100 - \text{air-drying loss})}{100}.$$

$$\text{Oxygen "as received"} = \text{oxygen} \times \frac{(100 - \text{air-drying loss})}{100} + \tfrac{8}{9}\ \text{air-drying loss}.$$

$$\text{Calories "as received"} = \text{calories} \times \frac{(100 - \text{air-drying loss})}{100}.$$

Calculation from analysis of "air-dried" coal to "dry coal."
All figures expressed in per cent.

$$\text{Volatile matter in "dry coal"} = \text{volatile matter} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Fixed carbon in "dry coal"} = \text{fixed carbon} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Ash in "dry coal"} = \text{ash} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Sulfur in "dry coal"} = \text{sulfur} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Hydrogen in "dry coal"} = (\text{hydrogen} - \tfrac{1}{9}\ \text{moisture}) \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Carbon in "dry coal"} = \text{carbon} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Nitrogen in "dry coal"} = \text{nitrogen} \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Oxygen in "dry coal"} = (\text{oxygen} - \tfrac{8}{9}\ \text{moisture}) \times \frac{100}{100 - \text{moisture}}.$$

$$\text{Calories in "dry coal"} = \text{calories} \times \frac{100}{100 - \text{moisture}}.$$

TENTATIVE VOLUME AND SPECIFIC GRAVITY CORRECTION TABLES FOR CREOSOTE, CREOSOTE COAL-TAR SOLUTION (UP TO 50 PER CENT TAR) AND COAL TAR (COKE-OVEN TARS)[1]

A.S.T.M. Designation: D 347 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1932.

These tables have been prepared by the U. S. Bureau of Standards to meet a demand from the wood preserving industry for convenient tables for reducing creosote volumes to the basis of 100° F. (38° C.) and for reducing specific gravity observations to the same temperature. Tables I and II give in parallel columns correction factors for creosote, and for mixtures of creosote and coal tar (up to 50 per cent tar) designated as solution, and for coal tar. They are based on density determinations made on a selected range of domestic and foreign creosote and domestic coke-oven tars.

Table I shows the volume occupied at 100° F. (33° C.) by a quantity of oil occupying a unit volume at the indicated temperature; for example, 1 gal. of creosote measured at 120° F. (49° C.) will have a volume of 0.9921 gal. at 100° F. (38° C.); thus, if the volume of creosote at 120° F. (49° C.) equals 10,000 gal., then the volume at 100° F. (38° C.) equals 10,000 times 0.9921 or 9,921 gal.

Table II gives corrections for observed specific gravity which are simply made by adding to the observed value for temperatures above 100° F. (38° C.) and subtracting for temperatures below 100° F. (38° C.).

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[1] Criticisms of this Tentative Standard are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

These tables have been adopted as tentative standard by the American Wood Preservers' Association and are being considered for adoption by the American Railway Engineering Association; they are the outcome of a Joint Conference Committee representing these associations and the American Society for Testing Materials.

TABLE I.—VOLUME CORRECTION TABLE FOR CREOSOTE, CREOSOTE COAL-TAR SOLUTION (UP TO 50 PER CENT TAR) AND COAL TAR (COKE-OVEN TARS).

The observed volume is to be multiplied by the factor corresponding to the observed temperature.

Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.9526	0.9542	0.9594	165	0.9743	0.9754	0.9783
219	0.9530	0.9546	0.9597	164	0.9747	0.9758	0.9786
218	0.9534	0.9550	0.9600	163	0.9751	0.9762	0.9789
217	0.9538	0.9554	0.9604	162	0.9754	0.9765	0.9793
216	0.9542	0.9557	0.9607	161	0.9758	0.9769	0.9796
215	0.9546	0.9561	0.9611	160	0.9762	0.9773	0.9800
214	0.9550	0.9565	0.9614	159	0.9766	0.9777	0.9803
213	0.9554	0.9569	0.9618	158	0.9770	0.9781	0.9806
212	0.9558	0.9573	0.9621	157	0.9774	0.9785	0.9810
211	0.9561	0.9577	0.9625	156	0.9778	0.9788	0.9813
210	0.9565	0.9581	0.9628	155	0.9782	0.9792	0.9816
209	0.9569	0.9584	0.9632	154	0.9786	0.9796	0.9820
208	0.9573	0.9588	0.9635	153	0.9790	0.9800	0.9823
207	0.9577	0.9592	0.9639	152	0.9794	0.9804	0.9827
206	0.9581	0.9596	0.9642	151	0.9798	0.9808	0.9830
205	0.9585	0.9600	0.9646	150	0.9802	0.9811	0.9833
204	0.9589	0.9604	0.9649	149	0.9806	0.9815	0.9837
203	0.9593	0.9608	0.9652	148	0.9810	0.9819	0.9840
202	0.9597	0.9611	0.9656	147	0.9814	0.9823	0.9844
201	0.9601	0.9615	0.9659	146	0.9818	0.9827	0.9847
200	0.9605	0.9619	0.9663	145	0.9822	0.9830	0.9850
199	0.9609	0.9623	0.9666	144	0.9826	0.9834	0.9854
198	0.9612	0.9627	0.9670	143	0.9830	0.9838	0.9857
197	0.9616	0.9631	0.9673	142	0.9834	0.9842	0.9860
196	0.9620	0.9634	0.9677	141	0.9838	0.9846	0.9864
195	0.9624	0.9638	0.9680	140	0.9842	0.9850	0.9867
194	0.9628	0.9642	0.9684	139	0.9846	0.9853	0.9870
193	0.9632	0.9646	0.9687	138	0.9850	0.9857	0.9874
192	0.9636	0.9650	0.9690	137	0.9853	0.9861	0.9877
191	0.9640	0.9654	0.9694	136	0.9857	0.9865	0.9880
190	0.9644	0.9658	0.9697	135	0.9861	0.9868	0.9884
189	0.9648	0.9662	0.9701	134	0.9865	0.9872	0.9887
188	0.9652	0.9665	0.9704	133	0.9869	0.9876	0.9890
187	0.9656	0.9669	0.9708	132	0.9873	0.9880	0.9894
186	0.9660	0.9673	0.9711	131	0.9877	0.9884	0.9897
185	0.9664	0.9677	0.9714	130	0.9881	0.9887	0.9900
184	0.9668	0.9681	0.9718	129	0.9885	0.9891	0.9904
183	0.9672	0.9685	0.9721	128	0.9889	0.9895	0.9907
182	0.9676	0.9688	0.9725	127	0.9893	0.9899	0.9910
181	0.9680	0.9692	0.9728	126	0.9897	0.9902	0.9914
180	0.9684	0.9696	0.9732	125	0.9901	0.9906	0.9917
179	0.9687	0.9700	0.9735	124	0.9905	0.9910	0.9920
178	0.9691	0.9704	0.9739	123	0.9909	0.9914	0.9924
177	0.9695	0.9708	0.9742	122	0.9913	0.9917	0.9927
176	0.9699	0.9712	0.9745	121	0.9917	0.9921	0.9930
175	0.9703	0.9715	0.9749	120	0.9921	0.9925	0.9934
174	0.9707	0.9719	0.9752	119	0.9925	0.9929	0.9937
173	0.9711	0.9723	0.9756	118	0.9929	0.9932	0.9940
172	0.9715	0.9727	0.9759	117	0.9932	0.9936	0.9944
171	0.9719	0.9731	0.9762	116	0.9936	0.9940	0.9947
170	0.9723	0.9735	0.9766	115	0.9940	0.9944	0.9950
169	0.9727	0.9738	0.9769	114	0.9944	0.9948	0.9954
168	0.9731	0.9742	0.9772	113	0.9948	0.9951	0.9957
167	0.9735	0.9746	0.9776	112	0.9952	0.9955	0.9960
166	0.9739	0.9750	0.9779	111	0.9956	0.9959	0.9964

TABLE I.—(*Continued.*)

The observed volume is to be multiplied by the factor corresponding to the observed temperature.

Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
110	0.9960	0.9962	0.9967	105	0.9980	0.9981	0.9983
109	0.9964	0.9966	0.9970	104	0.9984	0.9985	0.9987
108	0.9968	0.9970	0.9974	103	0.9988	0.9989	0.9990
107	0.9972	0.9974	0.9977	102	0.9992	0.9992	0.9993
106	0.9976	0.9978	0.9980	101	0.9996	0.9996	0.9997
				100	1.0000	1.0000	1.0000
The portion of the table below should not be used unless the oil is entirely free from crystals.							
99	1.0004	1.0004	1.0003	79	1.0083	1.0079	1.0070
98	1.0008	1.0008	1.0007	78	1.0087	1.0082	1.0073
97	1.0012	1.0011	1.0010	77	1.0091	1.0086	1.0076
96	1.0016	1.0015	1.0013	76	1.0095	1.0090	1.0080
95	1.0020	1.0019	1.0017	75	1.0099	1.0094	1.0083
94	1.0024	1.0022	1.0020	74	1.0103	1.0097	1.0086
93	1.0028	1.0026	1.0023	73	1.0107	1.0101	1.0089
92	1.0032	1.0030	1.0026	72	1.0111	1.0105	1.0093
91	1.0036	1.0034	1.0030	71	1.0115	1.0109	1.0096
90	1.0040	1.0038	1.0033	70	1.0118	1.0112	1.0099
89	1.0043	1.0041	1.0036	69	1.0122	1.0116	1.0103
88	1.0047	1.0045	1.0040	68	1.0126	1.0120	1.0106
87	1.0051	1.0049	1.0043	67	1.0130	1.0124	1.0109
86	1.0055	1.0052	1.0046	66	1.0134	1.0127	1.0112
85	1.0059	1.0056	1.0050	65	1.0138	1.0131	1.0116
84	1.0063	1.0060	1.0053	64	1.0142	1.0135	1.0119
83	1.0067	1.0064	1.0056	63	1.0146	1.0138	1.0122
82	1.0071	1.0067	1.0060	62	1.0150	1.0142	1.0126
81	1.0075	1.0071	1.0063	61	1.0154	1.0146	1.0129
80	1.0079	1.0075	1.0066	60	1.0158	1.0150	1.0132

TABLE II.—SPECIFIC GRAVITY CORRECTION TABLE FOR CREOSOTE, CREOSOTE COAL-TAR SOLUTION (UP TO 50 PER CENT TAR) AND COAL TAR (COKE-OVEN TARS).

Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity			Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.0491	0.0481	0.0451	200	0.0409	0.0400	0.0375
219	0.0487	0.0477	0.0447	199	0.0405	0.0396	0.0371
218	0.0483	0.0473	0.0443	198	0.0401	0.0392	0.0367
217	0.0479	0.0469	0.0439	197	0.0397	0.0388	0.0363
216	0.0475	0.0465	0.0436	196	0.0392	0.0384	0.0360
215	0.0471	0.0460	0.0432	195	0.0388	0.0379	0.0356
214	0.0467	0.0456	0.0428	194	0.0384	0.0375	0.0352
213	0.0462	0.0452	0.0424	193	0.0380	0.0371	0.0348
212	0.0458	0.0448	0.0420	192	0.0375	0.0367	0.0344
211	0.0454	0.0444	0.0417	191	0.0371	0.0363	0.0341
210	0.0450	0.0440	0.0413	190	0.0367	0.0359	0.0337
209	0.0446	0.0436	0.0409	189	0.0363	0.0355	0.0333
208	0.0442	0.0432	0.0405	188	0.0359	0.0351	0.0329
207	0.0438	0.0428	0.0401	187	0.0355	0.0347	0.0325
206	0.0434	0.0424	0.0398	186	0.0351	0.0343	0.0322
205	0.0430	0.0420	0.0394	185	0.0347	0.0339	0.0318
204	0.0426	0.0416	0.0390	184	0.0343	0.0335	0.0314
203	0.0422	0.0412	0.0386	183	0.0339	0.0331	0.0310
202	0.0418	0.0408	0.0382	182	0.0334	0.0327	0.0306
201	0.0413	0.0404	0.0379	181	0.0330	0.0323	0.0303

TABLE II.—(*Continued.*)

Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity			Observed Temperature deg. Fahr,	Add to Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
180	0.0326	0.0319	0.0299	140	0.0161	0.0158	0.0148
179	0.0322	0.0315	0.0295	139	0.0157	0.0154	0.0144
178	0.0318	0.0311	0.0291	138	0.0153	0.0150	0.0141
177	0.0314	0.0307	0.0288	137	0.0149	0.0146	0.0137
176	0.0309	0.0303	0.0284	136	0.0145	0.0142	0.0133
175	0.0305	0.0298	0.0280	135	0.0141	0.0138	0.0130
174	0.0301	0.0294	0.0276	134	0.0137	0.0134	0.0126
173	0.0297	0.0290	0.0272	133	0.0133	0.0130	0.0122
172	0.0293	0.0286	0.0269	132	0.0129	0.0126	0.0118
171	0.0289	0.0282	0.0265	131	0.0125	0.0122	0.0115
170	0.0284	0.0278	0.0261	130	0.0121	0.0118	0.0111
169	0.0280	0.0274	0.0257	129	0.0117	0.0114	0.0107
168	0.0276	0.0270	0.0254	128	0.0113	0.0110	0.0104
167	0.0272	0.0266	0.0250	127	0.0109	0.0106	0.0100
166	0.0268	0.0262	0.0246	126	0.0105	0.0102	0.0096
165	0.0264	0.0258	0.0242	125	0.0101	0.0098	0.0092
164	0.0260	0.0254	0.0238	124	0.0097	0.0094	0.0089
163	0.0256	0.0250	0.0234	123	0.0093	0.0090	0.0085
162	0.0252	0.0246	0.0231	122	0.0089	0.0087	0.0081
161	0.0248	0.0242	0.0227	121	0.0084	0.0083	0.0078
160	0.0244	0.0238	0.0223	120	0.0080	0.0079	0.0074
159	0.0239	0.0234	0.0219	119	0.0076	0.0075	0.0070
158	0.0234	0.0230	0.0216	118	0.0072	0.0071	0.0067
157	0.0230	0.0226	0.0212	117	0.0068	0.0067	0.0063
156	0.0226	0.0222	0.0208	116	0.0064	0.0063	0.0059
155	0.0222	0.0218	0.0204	115	0.0060	0.0059	0.0056
154	0.0218	0.0214	0.0200	114	0.0056	0.0055	0.0052
153	0.0214	0.0210	0.0197	113	0.0052	0.0051	0.0048
152	0.0210	0.0206	0.0193	112	0.0048	0.0047	0.0044
151	0.0206	0.0202	0.0189	111	0.0044	0.0043	0.0041
150	0.0202	0.0198	0.0186	110	0.0040	0.0039	0.0037
149	0.0198	0.0194	0.0182	109	0.0036	0.0035	0.0033
148	0.0194	0.0190	0.0178	108	0.0032	0.0031	0.0030
147	0.0189	0.0186	0.0174	107	0.0028	0.0027	0.0026
146	0.0186	0.0182	0.0170	106	0.0024	0.0023	0.0022
145	0.0182	0.0178	0.0167	105	0.0020	0.0020	0.0018
144	0.0177	0.0174	0.0163	104	0.0016	0.0016	0.0015
143	0.0173	0.0170	0.0159	103	0.0012	0.0012	0.0011
142	0.0169	0.0166	0.0155	102	0.0008	0.0008	0.0007
141	0.0165	0.0162	0.0152	101	0.0004	0.0004	0.0004
				100	0.0000	0.0000	0.0000

The portion of the table below should not be used unless the oil is entirely free from crystals.

Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity			Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
99	0.0004	0.0004	0.0004	79	0.0083	0.0082	0.0077
98	0.0008	0.0008	0.0007	78	0.0087	0.0086	0.0081
97	0.0012	0.0012	0.0011	77	0.0091	0.0090	0.0085
96	0.0016	0.0016	0.0015	76	0.0095	0.0094	0.0088
95	0.0020	0.0020	0.0018	75	0.0099	0.0097	0.0092
94	0.0024	0.0023	0.0022	74	0.0103	0.0101	0.0096
93	0.0028	0.0027	0.0026	73	0.0107	0.0105	0.0099
92	0.0032	0.0031	0.0030	72	0.0111	0.0109	0.0102
91	0.0036	0.0035	0.0033	71	0.0115	0.0113	0.0106
90	0.0040	0.0039	0.0037	70	0.0118	0.0117	0.0109
89	0.0043	0.0043	0.0040	69	0.0122	0.0121	0.0113
88	0.0047	0.0047	0.0044	68	0.0126	0.0124	0.0117
87	0.0051	0.0051	0.0048	67	0.0130	0.0128	0.0120
86	0.0055	0.0055	0.0052	66	0.0134	0.0132	0.0124
85	0.0059	0.0058	0.0055	65	0.0138	0.0136	0.0128
84	0.0063	0.0062	0.0059	64	0.0142	0.0140	0.0132
83	0.0067	0.0066	0.0063	63	0.0146	0.0144	0.0135
82	0.0071	0.0070	0.0066	62	0.0150	0.0148	0.0139
81	0.0075	0.0074	0.0070	61	0.0154	0.0152	0.0143
80	0.0079	0.0078	0.0074	60	0.0158	0.0155	0.0146

TENTATIVE METHOD OF SAMPLING NATURAL BUILDING STONE AND SAMPLE FOR TESTING[1]

A.S.T.M. Designation: D 355 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Standard Samples.

1. Whenever a sample of stone from any quarry or quarry ledge is to be submitted to a testing laboratory for physical tests in order to determine its compressive strength and other physical properties, regardless of whether weathering tests or the full range of physical tests are to be conducted, a sample of standard size and shape shall be furnished.

Sampling.

2. Samples shall be selected so as to represent a fair true average of the particular type, kind and grade of material on which the tests are desired. In order that perfectly sound samples may be obtained, regardless of whether mechanical or explosive quarrying processes are employed, the sample blocks shall not be taken from a slab or from the face of a quarry block that occurs adjacent to a channel-cut where mechanical quarrying is employed, or adjacent to the split face of the rock adjoining the fracture made by an explosive charge.

NOTE.—In view of the fact that the value of physical tests on any material is dependent upon the tests showing a true average for the particular product, it is a great mistake for a producer to select for purpose of tests the so-called best material that the particular quarry or ledge produces, as such material may give test values which are not truly representative of the particular product and by establishing such values for the particular stone, place the test values and specification requirements for that stone on a basis which cannot be met in commercial practice, resulting later as a hardship to the producer.

Preparation of Sample.

3. The sample shall be sawed or roughly dressed to a rectangular shape in a manner that will not stun or shatter the material. The finished block shall be either a type "A" or a type "B" standard sample, as shown in Figs. 1 and 2, depending upon the number of tests required, or the sample shall be a roughly squared block of a size not smaller than either type "A" or type "B" sample. Type "A" sample, Fig. 1, is required where a full range of physical tests

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 8, 1932.

is desired and type "B" sample, Fig. 2, where only compressive strength and absorption tests are desired.

Marking of Sample. 4. The direction of the grain (bedding planes or rift) shall be carefully marked on each sample.

Record Specimens. 5. From the standard sample, two record specimens shall be sawed from one end as shown in Figs. 1 and 2, leaving a sample block for testing of the size indicated. The ends of the record specimens shall be pitched off so as to produce slabs with projecting rock-face ends, approximately 6 by 12 in. in size and about 2 in. in thickness as shown in Figs. 1 and 2. One of these record specimens shall be retained by the quarry producer and the other shall be sent to the testing laboratory along with the sample block for testing.

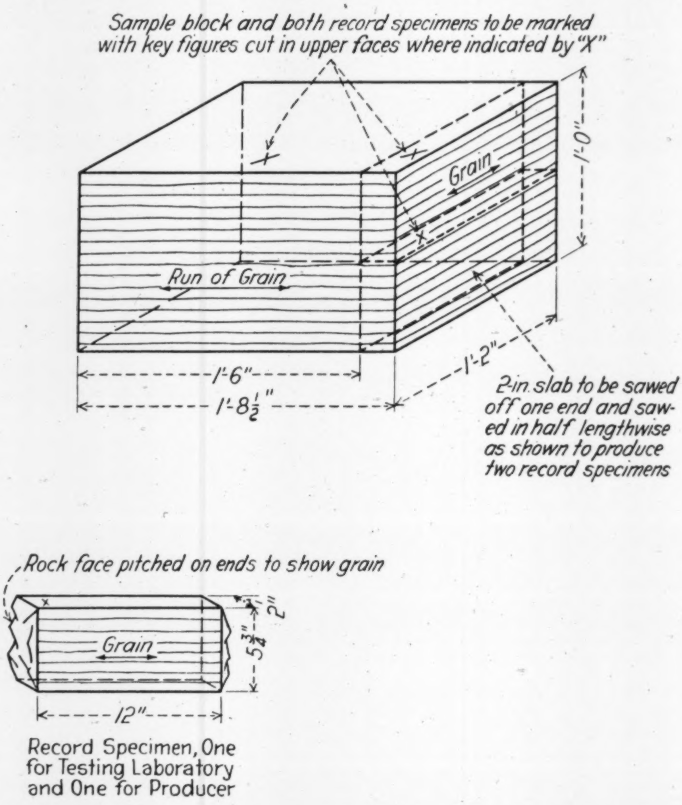

Sample block and both record specimens to be marked with key figures cut in upper faces where indicated by "X"
X
X
X
Grain
Run of Grain
1'-0"
1'-6"
1'-8½"
1'-2"
2-in. slab to be sawed off one end and sawed in half lengthwise as shown to produce two record specimens
Rock face pitched on ends to show grain
x
Grain
2"
5¾"
12"
Record Specimen, One for Testing Laboratory and One for Producer

FIG. 1.—Type "A" Standard Size Sample Block for Complete Series of Test Specimens and Record Specimens.

Identification of Samples. 6. The sample block for testing and both record specimens shall be marked, where indicated by "X" in Figs. 1 and 2, with a suitable number, letter or key-diagram cut into the upper sides of the stone with a chisel as a permanent means of identification. This lettering or key-diagram shall conform with the key that may be assigned to the particular quarry by the testing laboratory for record purposes.

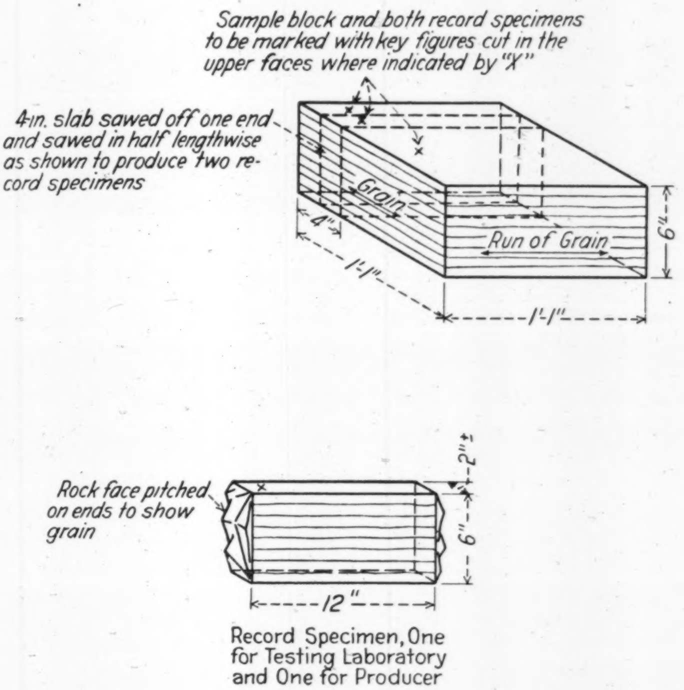

Sample block and both record specimens to be marked with key figures cut in the upper faces where indicated by "X"
4-in. slab sawed off one end and sawed in half lengthwise as shown to produce two record specimens
x
Grain
Run of Grain
4"
1'-1"
1'-1"
6"
Rock face pitched on ends to show grain
2"±
6"
12"
Record Specimen, One for Testing Laboratory and One for Producer

FIG. 2.—Type "B" Standard Size Sample Block for Compression and Absorption Test Specimens and Record Specimens.

Signed Statement to Accompany Samples for Testing.

7. A written statement shall accompany all samples sent to the testing laboratory stating the following information:

(*a*) The kind of stone (such as limestone, sandstone, granite, marble);

(*b*) The name and address of producing company or owner;

(*c*) The name of quarry, if it so happens the quarry has a specific name, or is one of several owned and operated by the one concern;

(*d*) The ledge, location or approximate position in said quarry from which the particular sample was taken;

(*e*) The grade or trade name of the particular variety of stone, if this material is marketed under any established grade or trade name;

(*f*) *Owner's Statement.*—The information specified in Paragraphs (*a*) to (*e*) shall be accompanied by the following statement signed by the producer, or by an authorized executive of the producing company, transmitting the sample:

This is to certify that the sample of stone and the accompanying record specimen sent to you for testing and designated by key number .... is, in our opinion, a true average sample of the grade and kind of stone as above described. This stone was quarried in the month of ...., 19.....

Signed.....................................
(Company)

By.....................................

APPENDIX

Test Specimens.—The manner in which the various types and sizes of test specimens may be cut from the standard sample block of stone is shown in Fig. 3 for type "A" sample, which provides specimens for a full range of physical tests, and in Fig. 4 for type "B" sample, which provides specimens for compressive strength and absorption tests. The test specimens shall conform to the requirements of the methods of test relating to natural building stone of the American Society for Testing Materials.

Number of Test Specimens.—The following minimum number of test specimens is recommended:

(*a*) *Compression.*—For a complete series of compression tests, twelve specimens shall be used, three for testing wet and three for testing dry, each way of the grain.

For ordinary compression tests in the dry condition, eight specimens shall be used, four each way of the grain.

(*b*) *Flexure.*—For flexure tests, nine specimens shall be used, three specimens each way of grain. For this test, slab specimens not smaller than 12 by 4 by 1 in. are recommended.

(*c*) *Shear.*—For shear tests, six specimens shall be used. These may be either the broken slabs left from the flexure test specimens or may be 1-in. slabs prepared especially for this purpose.

(*d*) *Tension.*—For tension tests, six bar specimens $1\frac{1}{2}$ by $1\frac{1}{2}$ in. in cross-section by about 10 in. in length shall be used, three specimens each way of the grain.

(*e*) *Elasticity.*—For elasticity tests, two bar specimens $3\frac{1}{2}$ by $3\frac{1}{2}$ in. in cross-section by 12 in. in length shall be used, one each way of the grain.

(*f*) *Impact or Hardness.*—For impact or hardness tests, six specimens shall be used, consisting of 1-in. diameter cylinders 1 in. in height.

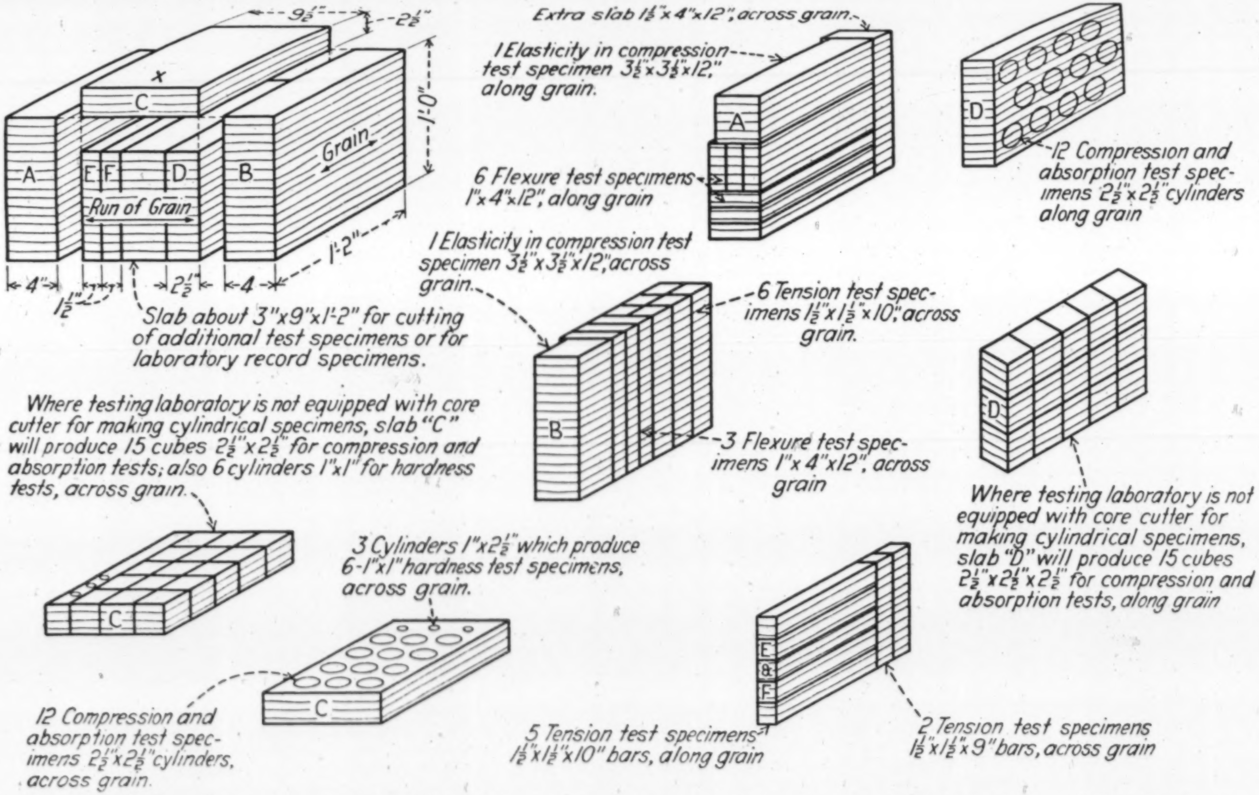
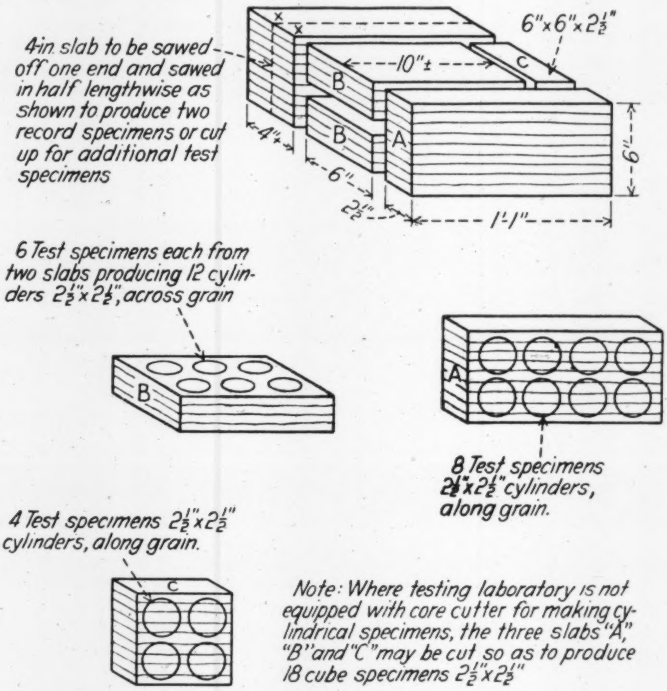

9½"
2½"
x
C
1'0"
A
E F
D
B
Grain
Run of Grain
1'2"
4"
1½"
2½"
4
Slab about 3"x9"x1'2" for cutting of additional test specimens or for laboratory record specimens.
Extra slab 1½"x4"x12", across grain.
1 Elasticity in compression test specimen 3½"x3½"x12," along grain.
A
6 Flexure test specimens 1"x4"x12", along grain
D
12 Compression and absorption test specimens 2½"x2½" cylinders along grain
1 Elasticity in compression test specimen 3½"x3½"x12",across grain.
B
6 Tension test specimens 1½"x1½"x10", across grain.
3 Flexure test specimens 1"x4"x12", across grain
D
Where testing laboratory is not equipped with core cutter for making cylindrical specimens, slab "D" will produce 15 cubes 2½"x2½"x2½" for compression and absorption tests, along grain
Where testing laboratory is not equipped with core cutter for making cylindrical specimens, slab "C" will produce 15 cubes 2½"x2½" for compression and absorption tests; also 6 cylinders 1"x1" for hardness tests, across grain.
C
3 Cylinders 1"x2½" which produce 6-1"x1" hardness test specimens, across grain.
C
12 Compression and absorption test specimens 2½"x2½" cylinders, across grain.
E
&
F
5 Tension test specimens 1½"x1½"x10" bars, along grain
2 Tension test specimens 1½"x1½"x9" bars, across grain

FIG. 3.—Diagram Showing How Type "A" Standard Sample Is Cut to Produce the Complete Series of Test Specimens.

(*g*) *Absorption.*—For absorption tests, three specimens of regular form shall be used, either cylinders, cubes or square prisms whose greatest dimension shall be not more than 3 in. and whose least dimension shall be not less than 2 in.


4-in. slab to be sawed off one end and sawed in half lengthwise as shown to produce two record specimens or cut up for additional test specimens
x
x
6"×6"×2½"
10"±
C
B
B
A
4"
6"
2½"
1'-1"
6"
6 Test specimens each from two slabs producing 12 cylinders 2½"×2½", across grain
B
A
8 Test specimens 2½"×2½" cylinders, along grain.
4 Test specimens 2½"×2½" cylinders, along grain.
C

Note: Where testing laboratory is not equipped with core cutter for making cylindrical specimens, the three slabs "A," "B" and "C" may be cut so as to produce 18 cube specimens 2½"×2½"

FIG. 4.—Diagram Showing How Type "B" Standard Sample Is Cut to Produce Test Specimens for Compression and Absorption Tests.

(*h*) *Freezing.*—For freezing tests, six specimens shall be used consisting of 2½-in. diameter cylinders about 2½-in. in height, three specimens each way of the grain.

Marking Test Specimens.—The load-bearing surfaces and the direction of the bedding planes or rift shall be carefully marked on each specimen after finishing.

TENTATIVE METHOD OF TENSION TESTING OF NATURAL BUILDING STONE[1]

A.S.T.M. Designation: D 356 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. This method of test is intended for the determination of the tensile strength of natural building stones used for exterior or interior construction or decorative purposes.

APPARATUS

Testing Machines. 2. Any type of standard testing machine may be used for the tension test provided the special gripping jaws shown in Fig. 1 are employed and so attached as to insure self aligning joints between these jaws and the heads of the testing machine, and avoid placing any bending or torsion stress upon the specimen.

NOTE.—If the tensile strength of the stone does not exceed 600 lb. per sq. in. the usual cement-briquet testing machine may be used provided it is equipped with the special jaws shown in Fig. 1. For stone of higher tensile strength or where such machines are not so equipped, the use of a testing machine of not over 20,000-lb. capacity is recommended.

TEST SPECIMENS

Test Specimens. 3. (*a*) Samples shall be representative of the material and shall consist of sections carefully sawed from apparently sound material, preferably quarry sample blocks or slabs. The direction of the bedding planes or rift shall be plainly marked on the sample. The sample shall be of sufficient size to allow the preparation of not less than three test specimens having the bedding planes or rift running in the proper direction for the kind of test or tests specified, that is, either parallel or perpendicular to the axis of the specimen through which tension is to be applied in the test.

(*b*) The specimens shall be square prism bars $1\frac{1}{2}$ by $1\frac{1}{2}$ in. in cross-section by about 10 in. in length. They shall be finished as closely as possible to a cross-sectional area of 2.25 sq. in. at the center section and may be of such length, either greater or less than the 10 in.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Accepted for publication as tentative by Committee E-10 on Standards, October 8, 1932.

specified, as required to fit properly into the gripping jaws of the type shown in Fig. 1.

(*c*) The specimens shall be cut from the original sample about $\frac{1}{16}$ in. full to the required finished dimensions of specimen with saws and then shall be brought to the required square prism form by grinding the sides true on a carborundum wheel or with abrasive powders and rubbing plates. Each of the four flat side surfaces of the specimens by this grinding shall be made as closely parallel to the side opposite as possible. No hand cutting with chisels or other tools will be permitted.

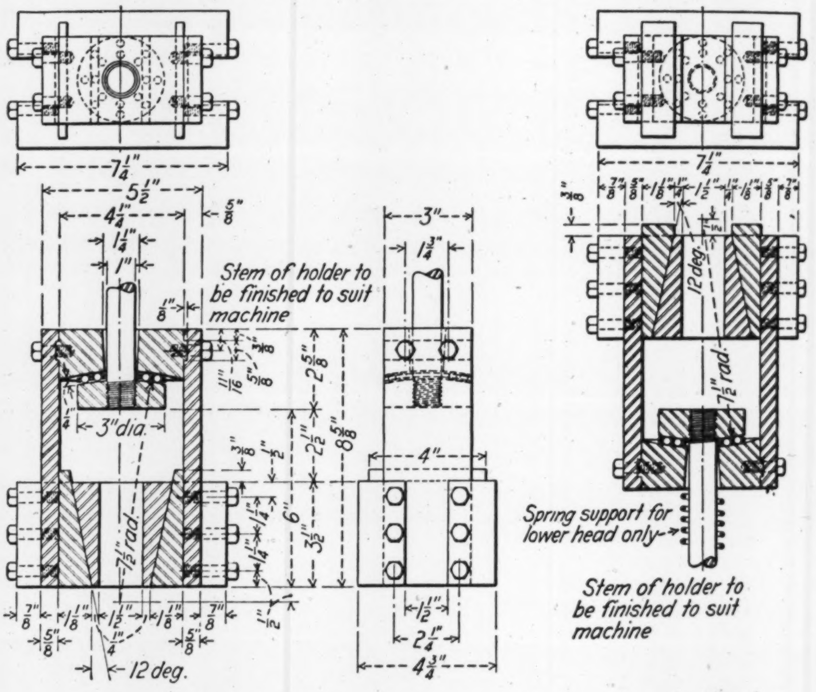
7¼"
5½"
4¼"
1¼"
1"
⅝"
⅛"
Stem of holder to be finished to suit machine
3"
1¾"
¼"
3" dia.
11/16"
⅝"
⅜"
2⅝"
8⅝"
⅜"
½"
2½"
6"
3½"
¼"
¼"
4"
7½" rad.
⅞"
1⅛"
1½"
1⅛"
⅞"
⅝"
¼"
⅝"
½"
12 deg.
1½"
2¼"
4¾"
Upper Head
7¼"
⅞"
⅝"
1⅛"
¼"
1½"
¼"
1⅛"
⅝"
⅞"
⅜"
1/16"
12 deg.
7½" rad.
Spring support for lower head only
Stem of holder to be finished to suit machine
Lower Head

FIG. 1.—Wedge Grips for Tension Test.

Marking Specimens. 4. The direction of the bedding planes or rift shall be carefully marked on each specimen after finishing.

Measurements. 5. The dimensions of the center section of the specimen shall be measured to the nearest 0.01 in.

PROCEDURE

Conditioning. 6. (*a*) *Dry Condition.*—Specimens to be tested in the dry condition shall be dried in an oven at from 110 to 120° C. for 24 hours immediately previous to the test.

(*b*) *Wet Condition.*—Specimens to be tested in the wet condition shall be completely immersed in water at room temperature for at least two weeks and shall be kept in water until immediately preceding the test.

Procedure. 7. The contact surfaces of the jaws and specimens shall be free from grit or dirt. The specimen shall be carefully gripped and centered in the jaws of the machine and the load then applied at a rate of approximately 600 lb. per minute. If a testing machine is used whereby the load is indicated by the balance of a beam, the beam shall be kept constantly in a floating position during the test.

Calculation. 8. The tensile strength in pounds per square inch shall be calculated from the following formula:

$$T = \frac{W}{A}$$

where T = the tensile strength in pounds per square inch.;

W = the total maximum load in pounds indicated by the testing machine; and

A = the area of the specimen at its center section in square inches.

Reporting Results. 9. (*a*) Each individual test shall be reported and for the tensile strength of the material the average of all tests shall be used, except where an individual result varies from the average of its group more than 25 per cent of that average, in which case that individual result shall be reported only as information.

(*b*) When the load has been applied on a line perpendicular to the bedding or rift planes the result shall be reported as "tensile strength in pounds per square inch perpendicular to the bedding or rift."

(*c*) When the load has been applied on a line parallel to the bedding or rift planes the result shall be reported as "tensile strength in pounds per square inch parallel to the bedding or rift."

Report. 10. The report shall include the following:

(*a*) The individual and average tensile strengths in pounds per square inch for each group of specimens;

(*b*) The average loaded area of specimens in each group;

(*c*) The condition of the specimen when tested, whether wet or dry;

(*d*) The direction of the application of the load relative to the bedding planes or rift of the specimens;

(*e*) A definite statement as to manner in which specimens were prepared and finished;

(*f*) The type of testing machine used.

TENTATIVE METHODS OF TESTING SHEET AND TAPE INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

A.S.T.M. Designation: D 149 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1924, 1926, 1927, 1930, 1931, 1932[2]

Scope. 1. These methods are intended to determine the dielectric strength of sheet and tape insulating materials except (*a*) rubber insulating tape, which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (A.S.T.M. Designation: D 119 - 32 T) of the American Society for Testing Materials,[3] and (*b*) friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69-32 T) of the American Society for Testing Materials.[4]

Since the dielectric strength of sheet and tape materials is dependent upon the time of application of the electrical tension, two tests differing in time duration are included as *A*, Short-Time Dielectric Strength Test, and *B*, One-Minute Step-by-Step Dielectric Strength Test, respectively.

A third test, designated as an Endurance Dielectric Strength Test, is included under *C*. It shows the relative dielectric strength of different flexible sheet and tape insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

It should be noted that the results obtained with the electrodes specified for sheet material will differ from those specified for tape material (Section 3) and will not be comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes

Sheet materials are divisible into two general classes: (1) thin, flexible materials, easily bent or wrapped around conductors, and (2) laminated materials, slightly flexible or rigid.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady N. Y.

[2] Latest revision accepted by Committee E-10 on Standards, August 11, 1932.

[3] See p. 930.

[4] See p. 926.

Tests on thin flexible materials at room temperature shall be made in accordance with Method *A* Short-Time Dielectric Strength Tests as specified in Sections 2 to 12; with Method *B* One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 22, or with Method *C* Endurance Dielectric Strength Test as specified in Sections 23 to 28.

Tests on laminated sheet materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Laminated Materials in Sections 29 to 32.

A. Short-Time Dielectric Strength Test

APPARATUS

High-Voltage Transformer.

2. (*a*) Any well-designed high-voltage transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

Electrodes.

3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

TEST SPECIMENS

Test Specimens.

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium.

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes.

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen.

7. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage.

9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kv. per second, except that if break-

down occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kv., the minimum time shall be reduced from 40 seconds to 20 seconds.

Number of Tests. 10. Ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness. 11. The thickness shall be the average of ten readings taken near the points of puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.24 in. nor more than 0.26 in. in diameter. In the case of tapes, the readings shall be taken along the center line of the specimen, nine of them between punctures and the tenth outside the first or last puncture.

Report. 12. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;
(*b*) Total volts and volts per mil of thickness at each puncture;
(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;
(*d*) The room temperature;
(*e*) The relative humidity, in per cent;
(*f*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

APPARATUS

Apparatus. 13. The apparatus shall consist of the high-voltage transformer and the electrodes specified in Sections 2 and 3.

TEST SPECIMENS

Test Specimens. 14. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium. 15. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 16. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 17. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

18. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 19. An initial voltage shall be applied equal to 40 per cent of the breakdown voltage in the short-time test, adjusted as shown in the following table. The voltage shall then be increased in increments as indicated in the table, up to failure, being held at each step for one minute. The change from each step to the next higher shall be made within 10 seconds.

Breakdown Kilovolts by Short-Time Method	Adjust 40 Per Cent of Breakdown Voltage to Nearest	Increment of Increase
12.5 kv. or less	0.5 kv.	0.5 kv.
over 12.5 to 25 kv., inclusive	1.0 "	1.0 "
over 25 " 50 " "	2.5 "	2.5 "
over 50 " 100 " "	5.0 "	5.0 "
over 100 "	10.0 "	10.0 "

NOTE.—*Example:*

Breakdown voltage by short-time method = 41 kv.
40 per cent of breakdown voltage = 16.4 kv.
Initial voltage obtained by adjusting 40 per cent of breakdown voltage to nearest 2.5 kv. = 17.5 kv.
Voltage will be increased in increments of 2.5 kv.
Therefore, second step = 20.0 kv., etc.

Number of Tests. 20. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness. 21. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 22. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;
(*b*) Total volts and volts per mil of thickness at each puncture;
(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;
(*d*) The room temperature;
(*e*) The relative humidity, in per cent;
(*f*) The duration of the test;
(*g*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

APPARATUS

Apparatus. 23. The apparatus shall consist of the high-voltage transformer specified in Section 2.

Test Specimen. 24. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets, on brass tubes. The tubes shall be, for sheets and for tape up to $1\frac{1}{2}$ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than $1\frac{1}{2}$ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen.

25. The specimen shall be mounted in an oven and a temperature of 100° C. (212° F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage.

26. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Method *A*) shall be applied and maintained for 30 minutes. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 minutes.

Temperature Readings.

27. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-minute period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report.

28. (*a*) The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(*1*) Duration of test;
(*2*) Breakdown voltage;
(*3*) Temperature of specimen at breakdown;
(*4*) Rate of temperature rise during test.

(*b*) The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

Dielectric Strength Tests on Laminated Materials:

29. For testing laminated sheet materials the procedure described in Method A, Short-Time Tests, Sections 2 to 12 and Method B, Step-by-Step Test, Sections 13 to 22 shall be modified in accordance with Sections 30 to 32.

Surrounding Medium.

30. All tests shall be made under oil maintained at normal room temperature.

Position of Electrodes and Specimen.

31. Tests may be transverse or parallel to the laminations, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the laminations, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by puring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the laminations, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

Number of Tests.

32. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method three tests.

Tests on Both Thin and Laminated Materials at Different Temperatures:

33. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

Apparatus.

34. Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin materials, or by the use of an oil bath, in the case of laminated materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

Procedure.

35. The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to half the thickness of the specimen in mils.

The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 32.

APPENDIX

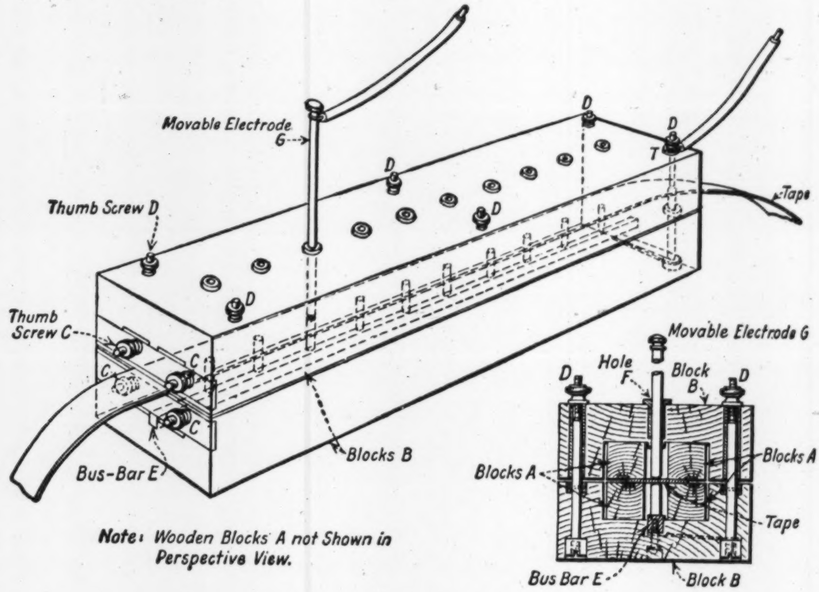
Figure 1 shows the multiple electrode form of tape tester. In this type, a strip of tape is held between four impregnated wooden blocks, *A*, which are in turn held in place in the two main blocks, *B*, by means of the thumb screws *C* in the ends of the blocks *A*. The blocks *A* are wound butt jointed with 1-in. varnished cloth tape. The whole device is clamped tightly together by the six thumb screws *D*.

There are ten lower electrodes which are fixed to a common bus-bar *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes *F* which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus-bar *E* through the thumb-screw terminal *D* marked *T*. The electrodes are cylindrical brass rods ¼ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until ten punctures have been obtained.

As more or less carbon is formed during tests, the successful operation of this device depends upon keeping the parts clean. The electrodes should be cleaned with very fine emery paper, being careful not to change their form. The blocks *A* should be rewound from time to time with new varnished cloth tape.

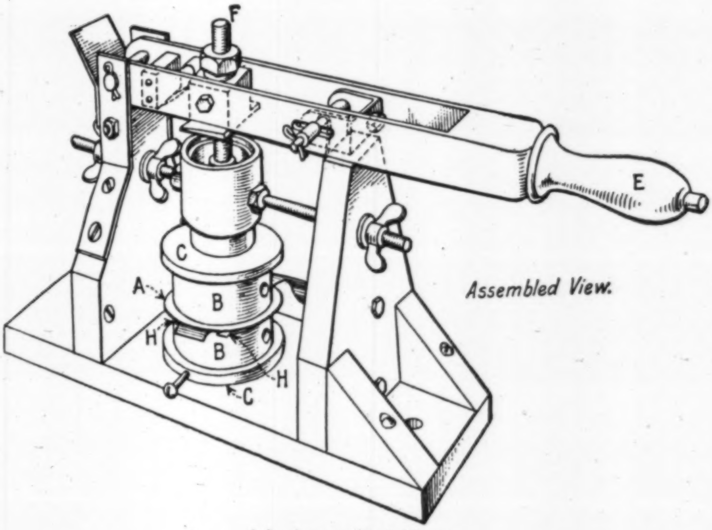
Referring to Fig. 2 (*a*), the tape is held between two pieces of fiber, *A*, which, in turn, are held between two impregnated wood blocks, *B*, held in brass bases, *C*. The blocks are pressed together by a spring, *D*, which is compressed by the latch handle, *E*, through a rounded pin, *F*, fitting into a cup-shaped cap, *G*. When the handle is released, the blocks are spread apart by two light springs, *H*, mounted on the face of the lower block. The electrodes, *J*, consist of hollow rods, fitted with very light internal springs, *K*, which hold the ends against the tape during the test. Vents, *L*, relieve any gas pressure which may develop when puncture occurs.


Movable Electrode G
D
D
T
Tape
Thumb Screw D
D
D
D
Thumb Screw C
C
C
C
C
Bus-Bar E
Blocks B
Movable Electrode G
Hole F
Block B
D
D
Blocks A
Blocks A
Tape
Bus Bar E
Block B

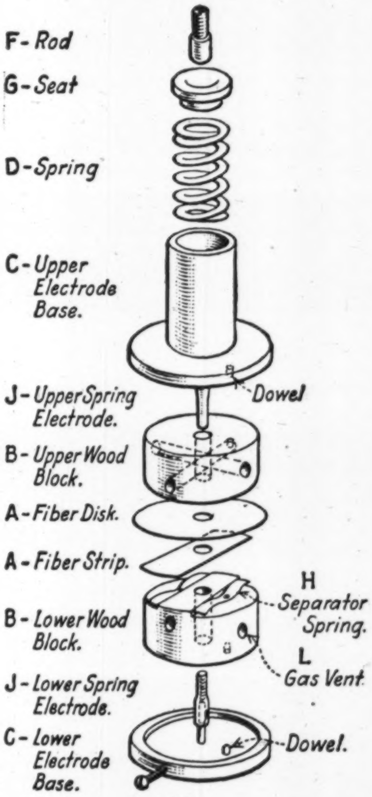
Note: Wooden Blocks A not Shown in Perspective View.

FIG. 1.—Apparatus for Dielectric Strength Test on Tape.

After considerable use, a leakage path will develop along the surface of one of the blocks and re-surfacing becomes necessary. This condition is avoided by using fiber disks as indicated in Fig. 2 (*b*). These disks are easily removed and replaced as necessary.


F
E
Assembled View.
C
A
B
H
B
H
C

(*a*) **Assembled View.**


F - Rod
G - Seat
D - Spring
C - Upper Electrode Base.
Dowel
J - Upper Spring Electrode.
B - Upper Wood Block.
A - Fiber Disk.
A - Fiber Strip.
H
Separator Spring.
B - Lower Wood Block.
L
Gas Vent
J - Lower Spring Electrode.
Dowel.
C - Lower Electrode Base.

(*b*)

FIG. 2.—Lever Operated Form of Tape Tester.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR POWER FACTOR AND DIELECTRIC CONSTANT[1]

A.S.T.M. Designation: D 150 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1927, 1931, 1932.

Scope.

1. These methods provide for the determination of the power factor and dielectric constant of solid electrical insulating materials at frequencies in the order of:

(*a*) 100 to 1500 kilocycles, the procedure being described in Sections 11 to 22, inclusive;

(*b*) 1000 cycles, the procedure being described in Sections 23 to 29, inclusive.

NOTE.—The committee has under consideration for publication a procedure to be followed in measurements at 60 cycles.

DEFINITIONS

Power Factor.

2. *Power Factor.*—The power factor of an insulating material is the ratio of the total power loss (watts) in the material to the product of voltage (volts) and current (amperes) in a capacitor in which that material is the dielectric.

Dielectric Constant.

3. *Dielectric Constant.*—The dielectric constant of an insulating material is the ratio of the capacitance of a capacitor in which that material is the dielectric to the capacitance of a similar capacitor in which the dielectric is a vacuum. (For practical purposes air dielectric is equivalent to a vacuum.)

Loss Factor.

4. *Loss Factor.*—For the purpose of these methods the loss factor of an insulating material is the product of its power factor and its dielectric constant.

THEORY OF TEST

Power Factor.

5. (*a*) *Series Notation.*—Any insulating material between two electrodes constitutes a capacitor. Such a physical capacitor may be represented by a capacitance C and a resistance R in *series* as shown in Fig. 1. The resistance R is called the equivalent series resistance

---

[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

and the capacitance C is called the equivalent series capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 2. The power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1} R\omega C$$

where R = the resistance in ohms;
ω = 2π times the frequency in cycles; and
C = the capacitance in farads.

Since, for small angles the sine is substantially equal to the tangent, the power factor equals $R\omega C$, approximately. This is correct to closer than 0.5 per cent of the power factor value for power factors up to 0.1. Where R is expressed in ohms, C in microfarads and the frequency, f, in kilocycles, this expression becomes:

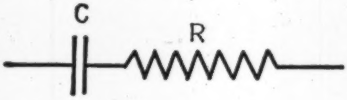


FIG. 1.—Equivalent Series Circuit.

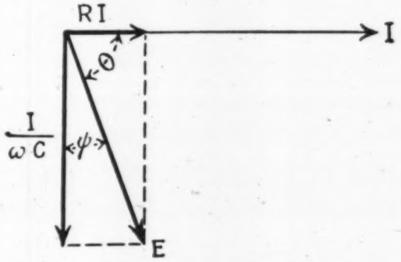


FIG. 2.—Vector Diagram for Equivalent Series Circuit.

$$\text{Power Factor} = 6.28\, RCf \times 10^{-3}$$

The power factor is, therefore, determined by measuring the values of R and C. This may be done by the Substitution Method as described in Sections 14 and 15.

(*b*) *Parallel Notation.*—A physical capacitor may also be represented by a capacitance C_p and a resistance R_p in *parallel* as shown in Fig. 3. The resistance R_p is called the equivalent parallel resistance and the capacitance C_p is called the equivalent parallel capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 4. For this notation the power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1}\frac{G}{\omega C_p}$$

where G = the conductance in *mhos;*
ω = 2π times the frequency, in cycles; and
C_p = the capacitance in farads.

Making the same approximations as in Paragraph (*a*), the power factor for practical purposes is taken as $\frac{G}{\omega C_p}$. Where G is expressed in micro-mhos, the frequency, f, in kilocycles, and C_p in micro-microfarads, this expression becomes:

$$\text{Power Factor} = 1.59 \frac{G\,10^2}{fC_p}$$

It will be seen that G and C_p determine the power factor. They may be measured by the Bridge Method as described in Sections 19 and 20.

The equivalent series capacitance C as determined by the Substitution Method, Sections 14 and 15, and the equivalent parallel capacitance C_p as determined by the Bridge Method, Sections 18 and 19, are not identical; but for power factors up to 0.1 they are equal to within 1 per cent. Either value may be used in calculating the dielectric constant.

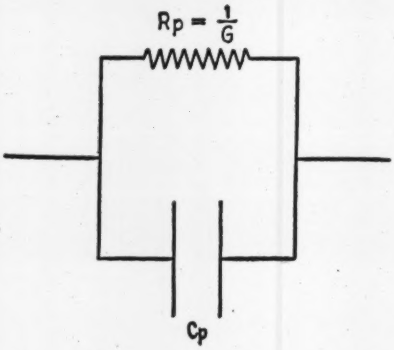


FIG. 3.—Equivalent Parallel Circuit.

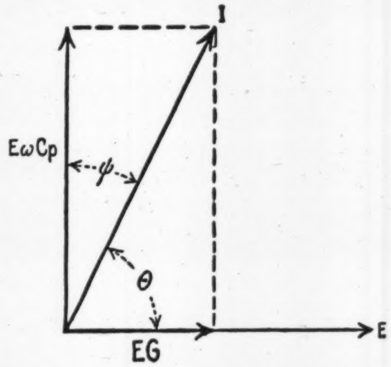


FIG. 4.—Vector Diagram for Equivalent Parallel Circuit.

Dielectric Constant. 6. (*a*) *Sheet Materials.*—For sheet materials, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{(C - C_e)t}{0.0885A}$$

where t = the average thickness of dielectric between electrodes, in centimeters;

A = the contact area of either of the equal electrodes in square centimeters;

C = the measured capacitance in micro-microfarads;

C_e = the edge correction obtained from the curve in Fig. 5.[1]

The determination of C_e requires a knowledge of the approximate value of K which can always be obtained by making a preliminary calculation, neglecting C_e in the above formula. For thickness t, in inches, and area A, in square inches, the above formula becomes:

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[1] For details of the determination of the edge correction, see E. L. Hoch, *Bell System Journal*, Vol. V, pp. 555–572c, October, 1926.

$$\text{Dielectric constant, } K = \frac{(C - C_e)\,t}{0.224\,A}$$

(*b*) *Tubes.*—For materials in the form of tubes, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{3.6\,t\,(C_1 - C_2)}{D\,(l_1 - l_2)}$$

where t = the thickness of the tube in centimeters;
D = the mean diameter in centimeters;

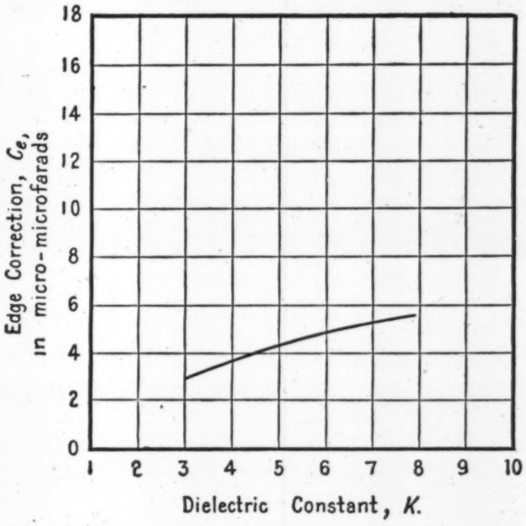

FIG. 5.—Edge Correction Curve for 4.5-in. Diameter Electrodes

C_1 = the measured capacitance in micro-microfarads when the electrodes have a length of l_1 centimeters; and
C_2 = the measured capacitance in micro-microfarads when the electrodes have a length of l_2 centimeters.

NOTE.—The two measurements C_1 and C_2 are made with different electrode lengths l_1 and l_2 for correction of edge effect.

If the tube thickness is so small, or the electrode length so large that the edge correction may be neglected, then the dielectric constant, K, may be calculated from the following:

$$\text{Dielectric constant, } K = \frac{3.6\,t\,C}{D\,l}$$

where C = the measured capacitance in micro-microfarads for electrodes of length l centimeters.

Loss Factor. 7. The total power loss per unit volume of insulating material for a stated frequency, voltage gradient, and temperature, is proportional to the product of the power factor and dielectric constant. Therefore, the loss factor is defined as:

Loss Factor = Power Factor × Dielectric constant, K

TEST SPECIMENS

Test Specimens. 8. (*a*) *Molded or Sheet Materials.*—For testing molded or sheet materials the test specimen shall be either a disk 6 in. (15.24 cm.) in diameter or a square 6 in. (15.24 cm.) on a side. The thickness shall preferably not be less than 0.1 in. (0.254 cm.) nor more than 0.3 in. (0.762 cm.). The thickness shall be uniform to ±5 per cent, and the surfaces shall be smooth and free from irregularities. Other thicknesses may be used where it is desired to test materials of the various thicknesses in commercial use. In any case, the capacitance of the specimen shall preferably not be less than 100 micro-microfarads.

(*b*) *Films.*—For testing films of insulating varnish, lacquer, or paints, the test specimen shall be prepared as specified for the dielectric strength tests in Appendix II to the Tentative Methods of Testing Varnishes Used for Electrical Insulation (A.S.T.M. Designation: D 115 - 31 T) of the American Society for Testing Materials.[1] The copper or brass plate shall be one capacitor plate, and tin-foil the other. Both varnish films may be tested individually.

(*c*) *Tubes.*—For testing rolled or molded laminated tubes, the test specimen shall have the diameter and wall thickness of the material it represents, and shall be of sufficient length to provide a capacitance of not less than 100 micro-microfarads. The thickness shall be uniform to ± 5 per cent, and the surfaces shall be smooth and free from irregularities.

Conditioning of Test Specimens. 9. Before the specimens are tested, they shall be kept for 48 hours under uniform atmospheric conditions. Unless otherwise specified, these conditions shall be a relative humidity of 60 per cent and a temperature of 20 to 30° C. A satisfactory method of maintaining constant humidity is given in Section 13 of the Tentative Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257 - 32 T) of the American Society for Testing Materials.[2]

Electrodes. 10. (*a*) *Molded or Sheet Materials.*—The electrodes shall consist of tin or lead-foil disks 4.5 in. (11.43 cm.) in diameter and approximately 0.001 in. or 0.002 in. (0.025 or 0.050 mm.) in thickness. They shall be applied to the surface of the specimen and shall be accurately centered with respect to each other and approximately with respect to the specimen. A very thin coating of petrolatum shall be used as an adhesive.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 866 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 813.

[2] See p. 879.

(*b*) *Films.*—For testing materials of thickness less than 0.1 in. (0.254 cm.), such as thin-sheet insulating materials and films of insulating varnish and lacquer, the electrode area may be adjusted to give any convenient capacitance above 100 micro-microfarads. When calculating the dielectric constant of such materials, the edge correction should be omitted.

(*c*) *Tubes.*—The outer electrode shall consist of tin or lead foil. The inner electrode shall consist either of tin or lead foil, or of mercury. The electrodes shall completely cover the tube surfaces to within $\frac{1}{4}$ in. of the ends of the specimen, shall be centered approximately with respect to the length of the specimen, and shall be located exactly opposite each other.

NOTE.—A very thin coating of petrolatum is a good adhesive for the foil. A cork or a wax plug provides means for holding the mercury in the tube.

PROCEDURE AT FREQUENCIES IN THE ORDER OF 100 TO 1500 KILOCYCLES

11. (*a*) The method of measurement may be either the substitution method as described in Sections 12, 13, 14 and 15, or the Bridge method as described in Sections 16, 17, 18, 19 and 20. **Method.**

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon between the supplier and the purchaser. Unless otherwise agreed upon the frequencies shall be approximately 100 kilocycles and 1000 kilocycles. **Measurements.**

A. Substitution Method

APPARATUS

12. *Oscillator.*—The generating circuit for the Substitution Method shall consist of an oscillator (preferably a vacuum tube) which is the power source. This oscillator shall be designed so as to be easily adjustable over a range of frequencies from 100 to 1500 kilocycles, and shall have a power rating sufficient to prevent any reaction on frequency or voltage output when coupled to the measuring circuit. The oscillator output shall be of approximately sine-wave form, having not more than 5-per-cent harmonic components. The oscillator shall be well shielded. The entire apparatus shall be installed in a well-shielded room or so located as to be free from interference. **Generating Circuit.**

Measuring Circuit. 13. The measuring circuit is shown in Fig. 6 and shall consist of the following parts:

Coupling Coils.—Several coupling coils so designed as to tune over the required frequency range to within 1 per cent of the frequency desired. For convenience in tuning, an adjustable air capacitor of about 0.001 micro-farads capacity (tuning capacitor) may be connected across the coupling coil. This tuning capacitor should be of the same sensitivity of adjustment as the standard air capacitor, but no calibration is necessary.

Capacitor.—An adjustable standard air capacitor having a capacitance of about 0.001 microfarad capable of being read to 0.5 micromicrofarad. This capacitor shall be calibrated for capacitance and power factor over the required frequency range.

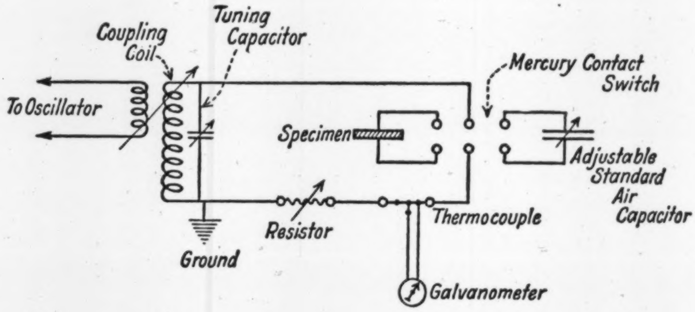

FIG. 6.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method.

Switch.—A special high-frequency switch of the mercury contact type having mercury cups mounted on Pyrex or quartz tubes 4 to 6 in. (10 to 15 cm.) in length. This switch shall be a double-pole, double-throw, with copper switch blades well amalgamated with mercury.

Thermocouple Galvanometer.—The thermocouple shall have a low heater resistance, preferably less than 2 ohms, and be sufficiently sensitive for use with a suitable galvanometer. The galvanometer shall be of low resistance and short period and shall be operated critically damped. It shall have a sensitivity of approximately 120 mm. per micro-ampere at a scale distance of 1 meter.

Resistors.—Several resistors made of short, straight lengths of non-magnetic resistance wire (advance or manganin is preferable) sealed into glass tubes (which may be evacuated if desired). These resistors shall all have approximately the same length. For most work, 30 resistors to cover a range of 0.2 to 60 ohms will suffice. When resistance values higher than 60 ohms are required, a 3-dial 1000-ohm non-reactive decade box may be used.

METHOD

Operation.

14. (*a*) *Procedure.*—With the specimen connected to the measuring circuit through the mercury contact switch, the circuit shall be tuned to approximately the desired frequency by proper selection of the coupling coil. The circuit may be brought into exact resonance by adjusting the frequency of the oscillator, or by means of the tuning capacitor if the latter is used. Resonance is indicated by maximum deflection of the galvanometer. The coupling to the oscillator shall be varied at the same time so that with no resistance inserted in the measuring circuit, approximately a two-third scale deflection of the galvanometer is obtained.

The adjustable standard air capacitor and a resistor shall then be substituted for the specimen. The resistance should be so chosen that when the measuring circuit is tuned to resonance by adjusting the standard air capacitor, a maximum deflection will be obtained on the galvanometer which is approximately the same as that previously produced by the specimen. Four resistors shall then be chosen having resistance values such that when inserted in the circuit, two will give deflections above and two below the deflection produced by the specimen. The deflections obtained with these four resistors shall be plotted against their resistance values. From this curve the equivalent series resistance R of the specimen shall be obtained by reading the value of resistance corresponding to the deflection produced by the specimen and adding to it the value of the resistance of the standard capacitor at the capacitance and test frequency used.

When a decade resistor is used, the procedure is the same as above except that it is sufficient to adjust the resistor to obtain a deflection equal to that produced by the specimen. The equivalent series resistance R is then equal to the dial reading of the resistance box plus the resistance of the standard air capacitor at the capacitance and test frequency used.

The capacitance reading of the standard air capacitor corrected for lead capacitance is the equivalent series capacitance C of the specimen.

The frequency shall be determined after the final tuning.

(*b*) *Alternative Procedure.*—The circuit for the alternative substitution method is shown in Fig. 7 and consists of a coupling coil, capacitor, switch, thermocouple galvanometer, and resistors as for the Substitution Method and conforming to the requirements of Section 13.

The standard capacitor shall be tuned to resonance, first, with the specimen in parallel and then alone in the circuit. The manipulation and calculations shall be made as follows: With the resistance, R, set to zero and the specimen, C_x, in parallel with the adjustable standard air capacitator, C_s, tune C_s to resonance, read the value of C_s (equals C_1) and the galvanometer deflection d_1. Disconnect the specimen and tune C_s to resonance and read (equals C_2), add resistance R_1, to make galvanometer deflection equivalent to d_1, calculate C_x and R_x from the following formulas:

$$C_x = C_2 - C_1$$

$$R_x = R_1 \left(\frac{C_2}{C_x}\right)^2$$

The power factor shall be calculated from the following formula:

$$\text{Power Factor} = 2\,\pi\, f\, C_x\, R_x$$

where f is expressed in cycles, C_x is expressed in farads and R_x is expressed in ohms.

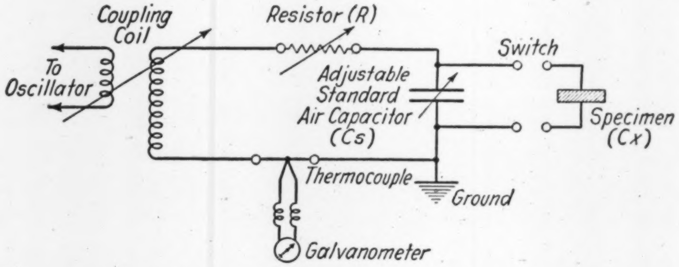

FIG. 7.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method (Alternative Procedure).

Calculations. 15. Calculations for power factor shall be made as described in Section 5 (*a*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

B. Bridge Method

APPARATUS

Generating Circuit. 16. The generating circuit for the Bridge Method shall be the same as for the Substitution Method as described in Section 12.

NOTE.—The oscillator does not need to be of as high a power output for the Bridge Method as for the Substitution Method.

Measuring Circuit.

17. The measuring circuit is shown in Fig. 8 with necessary shielding as indicated, and shall consist of the following parts:

Balanced Resistors.—One pair of balanced non-reactive resistors or ratio arms, *AB* and *BC*, each of approximately 250 ohms resistance, and enclosed in an electrostatic shield as shown in Fig. 8. These arms shall be balanced for resistance to within 0.05 of 1 per cent, and for reactance to within 0.1-micro-microfarad equivalent parallel capacitance.

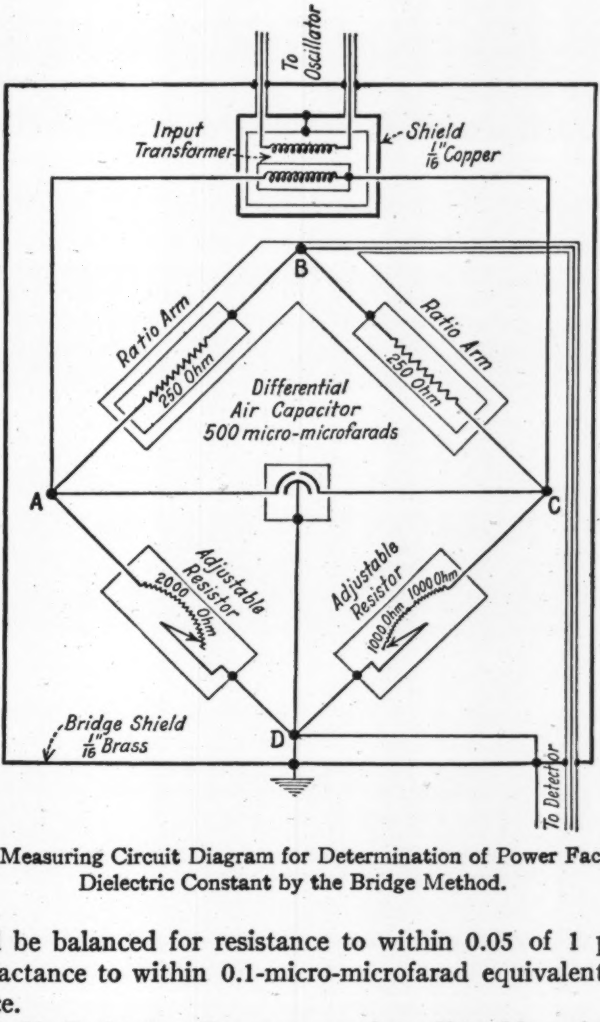
To Oscillator
Input Transformer
Shield $\frac{1}{16}$" Copper
B
Ratio Arm
250 Ohm
Ratio Arm
250 Ohm
Differential Air Capacitor 500 micro-microfarads
A
C
Adjustable Resistor
2000 Ohm
Adjustable Resistor
1000 Ohm
1000 Ohm
Bridge Shield $\frac{1}{16}$" Brass
D
To Detector

FIG. 8.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Bridge Method.

Adjustable Resistors.—Two non-reactive adjustable resistors each shielded as shown, for use in the *AD* and *CD* arms of the bridge. The *CD* arm resistor shall comprise two 1000-ohm steps. The *AD* arm resistor shall be a four-dial decade box having steps of 0.1, 1, 10, and 100 ohms, with an additional 1000-ohm step. Precision type, high-frequency commercial resistances are satisfactory for use in these resistors.

Differential Air Capacitor.—One differential air capacitor of 500-micro-microfarad capacitance, total variation. For convenience it is desirable to provide a vernier capacitor adjustable to 0.01 micro-microfarad. These capacitors shall be calibrated to read the capacitance inserted in the *CD* arm.

Input Transformer.—One shielded input transformer[1] adapted to the connection of a 250-ohm impedance to the oscillator.

Detector Circuit. 18. The detector circuit shall consist of any suitable detector of sufficient sensitivity to indicate an unbalance of 0.1 ohm in the *AD* bridge arm. A heterodyne type used with a telephone receiver will be found satisfactory.

METHOD

Operation. 19. Suitable leads for connecting to the specimen shall be connected to terminals *C* and *D* of the bridge, Fig. 8, but not to the specimen. The bridge shall then be balanced by adjusting the differential air capacitor and the adjustable arm resistor *AD*. The capacitance and resistance values are then recorded as C_o and R_o. These readings shall be taken to compensate for the capacitance in the bridge and lead wires. The specimen shall then be connected to the lead wires, and the bridge balanced again. The capacitance and resistance values are recorded as C_1 and R_1. The equivalent parallel capacitance of the specimen is: $C_p = C_1 - C_o$, and the conductance $G = \frac{R_o - R_1}{R_o \times R_1}$. By properly adjusting the value of R_o, G can be made substantially equal to $R_o - R_1$ times some power of ten.

The frequency shall be determined when the bridge is finally balanced.

Calculations. 20. Calculations for power factor shall be made as described in Section 5 (*b*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

ACCURACY

Accuracy. 21. The accuracy of the power factor and dielectric constant determinations by the above methods depend critically upon the care exercised in setting up the measuring equipment and in its subsequent manipulation. The technique exercised in these respects shall be such that an accuracy within ± 10 per cent for the determination of power factor, within ± 5 per cent for the determination of the dielectric constant of sheets, and within ± 10 per cent for the determination of the dielectric constant of tubes shall be obtained.

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[1] For general features of such a transformer, see "A Shielded Bridge for Inductive Impedance Measurements at Speech and Carrier Frequencies," by W. J. Shackelton, *Journal*, Am. Inst. Electrical Engrs., February, 1927, p. 159

REPORT

22. The report shall include the following:

Report.

(*a*) The power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in micro-microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in kilocycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

PROCEDURE AT FREQUENCIES IN THE ORDER OF 1000 CYCLES

Method.

23. (*a*) The method of measurement shall be the bridge method and may be any one of those described in Sections 24 to 27. Slight modifications of any one of these methods may be used with equally satisfactory results.

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon. Unless otherwise specified, the frequency shall be 1000 cycles.

APPARATUS

Generating Circuit.

24. *Power Source.*—The generating circuit may be a vacuum tube oscillator, a motor driven generator, or a tuning fork or other satisfactory source of 1000 cycles. The source shall be of approximately sine-wave form, having not more than 5-per-cent harmonic components.

Measuring Circuit.

25. Satisfactory measuring circuits, shown in Figs. 9, 10 and 11, are as follows:

(*a*) Figure 9 shows a measuring circuit where C_1 is an auxiliary air capacitor of about 4500 micro-microfarads, C_2 is the specimen being measured or a standard air capacitor. R_1, R_2, R_3, and R_4 are decade resistors. L_1 and L_3 are variable inductors each having a maximum of 12 millihenries and a minimum of 3 millihenries inductance; L_2 and L_4 are fixed inductors each of 11 millihenries. For power factors of less than 0.05 the resistance of the combinations $R_1 + L_1$, $R_2 + L_2$, $R_3 + L_3$ and $R_4 + L_4$ shall be 1000 ohms. For power factors greater than 0.05 these resistances shall be 500 ohms. The capacitance of the test specimen should be between 1000 and 3500 micro-microfarads. For this circuit very satisfactory results have been obtained without increasing the shielding over that built into the air capacitors. A 1000-cycle generator giving about 55 volts on the specimen may be used in this set-up as a source of power.

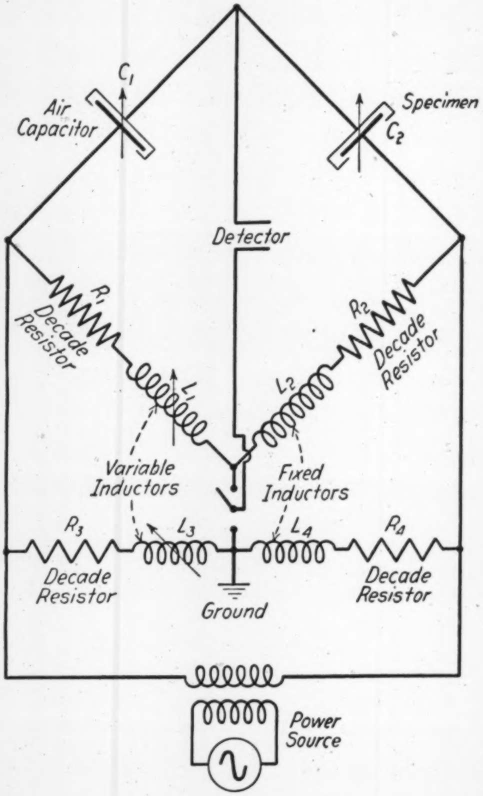

C_1
Air Capacitor
Specimen
C_2
Detector
R_1
Decade Resistor
R_2
Decade Resistor
L_1
L_2
Variable Inductors
Fixed Inductors
R_3
L_3
L_4
R_4
Decade Resistor
Ground
Decade Resistor
Power Source

FIG. 9.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

(*b*) Figure 10 shows a measuring circuit where R_1 and R_2 are each 5000 ohms. C_1 is a standard air capacitor, C_s is a standard balancing capacitor of at least 1000 micro-microfarads and C_x is the test specimen. R_3 is a balancing variable resistor of 11,110 ohms which may be thrown in either arm of the bridge containing capacitors. One dial of 0.1 ohm is desirable in this resistor. This set-up may be used satisfactory with any of the following sources of power: a tuning fork, a vacuum tube oscillator and a 1000-cycle generator. The capacitance of the test specimen shall be not less than 100 micro-microfarads. The entire bridge proper is shielded except the leads to the capacitors and the specimen. It has been found desirable to enclose the entire set-up with exception of the oscillator and the detecting device in an earthed metal box.

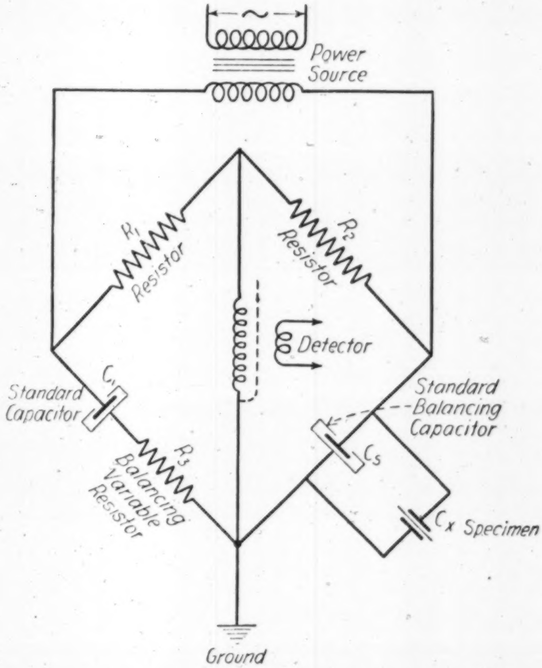
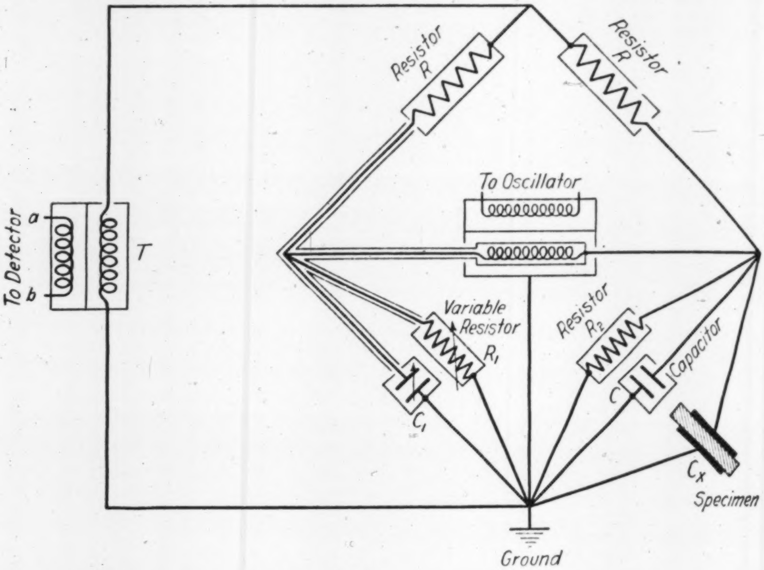

Power
Source
R_1
Resistor
R_2
Resistor
Detector
C_1
Standard
Capacitor
Standard
Balancing
Capacitor
C_s
R_3
Balancing
Variable
Resistor
C_x Specimen
Ground

Fig. 10.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

(*c*) Figure 11 shows a measuring circuit in which the two (ratio) arms each contain a resistance, R, of 1000 ohms; R_2 is 10,000 ohms; R_1 is a variable resistor from 0 to 10,000 ohms in steps of 0.01 ohm; C_x is the test specimen; C is a variable air condenser, the maximum value of which need not exceed 200 micro-microfarads and the calibration of which need not be known; C_1 is a variable standard air condenser with a maximum capacitance greater than the maximum value of $C_x + C$. An oscillator may be used with this set-up which gives about 3 to 8 volts across the specimen. The method is suitable for measurements on test specimens as low as 50 micro-microfarads. It has been found desirable to entirely shield the set-up except for the leads to the test specimen.

NOTE.—Transformer, *T*, Fig. 11, is not necessary if one terminal of the detector may be grounded at *a* or *b*, and with rare exceptions this may be done. The resistors should be specially selected for use in alternating currents of relatively high frequency.

Detector Circuit. 26. The detector circuit shall consist of any suitable detector, head phones, string galvanometer, etc., which has a sufficient sensitivity to give values of the power factor accurate to ±5 per cent.



R Resistors, fixed, 1000 ohms each
R_1 Resistor, variable, 10,000 ohms
R_2 Resistor, fixed, 10,000 ohms
C Capacitor, variable, 200 micro-microfarads maximum
C_1 Capacitor, variable, capacity greater than $C + C_x$
C_x Test specimen
T Detector Transformer

FIG. 11.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

METHOD

Operation. 27. The procedure in making the measurements shall be such as to enable the operator to determine the capacitance of the test specimen and also its equivalent resistance. The actual manipulation in this regard will depend upon the exact circuit chosen.

Calculation. 28. (*a*) *Power Factor.*—The calculation of the power factor shall be made as described in Section 5 (*a*) and (*b*) with proper modifications as given in the following paragraphs in order to conform to the particular set-up used:

When the measuring circuit described in Section 25 (*a*), Fig. 9, is used, the formula for calculation of the power factor reduces to the following:

$$\text{Power factor} = 2\,\pi\,f\,\frac{(L_2 - L_1)}{R_1}$$

Where L_2 and L_1 are in henries, R_1 is in ohms, and f is in cycles.

When the measuring circuit described in Section 25 (*b*), Fig. 10, is used, the formula for calculation of the power factor is as follows:

$$\text{Power factor} = 2\pi f C_x R_x \times 10^{-12}$$

where C_x = difference in capacitance of the standard capacitor with specimen in and out;

f = the frequency in cycles;

$R_x = (R' - R)\,\dfrac{C'^{\,2}_s}{C_x^{\,2}}$, where

R' = value of R_3 with specimen out;
R = value of R_3 with specimen in;
C'_s = capacitance of the standard capacitor with specimen out;
C_s = capacitance of the standard capacitor with specimen in;
$C_x = C'_s - C_s$

All values of capacitance in micro-microfarads; resistance is in ohms.

When the measuring circuit described in Section 25 (*c*), Fig. 11, is used, the formula for calculation of the power factor is as follows:

$$\text{Power factor} = \frac{G \times 10^{12}}{2\pi f C_p}$$

where G = the conductance of specimen in mhos calculated as follows:

$$G = \frac{R' - R}{R' \times R},\ \text{where}$$

R' = resistance R_1 with specimen out; and
R = resistance of R_1 with specimen in.

f = the frequency in cycles

C_p = the capacitance of the specimen calculated from the equation: $C_p = C'_s - C_s$

C'_s = capacitance of the standard C_1 with specimen in, and
C_s = capacitance of C_1 with specimen out.

All values of capacitance in micro-microfarads; resistance is in ohms.

(*b*) *Dielectric Constant.*—The calculation of the dielectric constant shall be made as described in Section 6.

(*c*) *Loss Factor.*—The calculation of the loss factor shall be made as described in Section 7.

REPORT

Report. 29. The report shall include the following:

(*a*) The power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in micro-microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in cycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

TENTATIVE METHODS OF TESTING UNTREATED PAPER USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 202 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926, 1927, 1928, 1929, 1930, 1932.

Scope. 1. These methods are intended to apply to untreated paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

SAMPLING

Sampling. 2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken.

NOTE.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity, moisture content, size,[2] ash and for identification of fibers[2] shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq.cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials. General Electric Co., Schenectady, N. Y.

[2] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance,[1] air resistance, dielectric strength and thickness.

MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

Note.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

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[1] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

Report.

7. The moisture content shall be expressed:

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

THICKNESS[1]

Apparatus.

8. (*a*) The instrument used for determining thickness by *Method A* shall be a 1-in. machinist's type micrometer constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet mechanism having a coil spring, pin-type pawl, and having anvil and spindle surfaces $\frac{1}{4}$ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, wear of micrometer screw, micrometer screw error tolerances and ratchet pressure specified in Section 9 (*d*), (*e*), (*f*), (*g*), (*h*) and (*i*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

(*b*) The instrument used for determining the thickness by *Method B* shall be a 1-in. machinist's type micrometer equipped with vernier but without a ratchet device and shall have anvil and spindle surfaces $\frac{1}{4}$ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, and micrometer screw error tolerances specified in Section 9 (*d*), (*e*), (*f*) and (*h*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

Cleaning Micrometer Surfaces.

9. (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of bond paper and moving the paper between the surfaces.

Procedure in Calibrating Method A Instruments.

(*b*) The manipulative procedure for calibrating controlled pressure instruments used in *Method A*, shall be in accordance with the following:

The micrometer shall be closed on the gage or calibrating device and then opened 4 or 5 mils (0.004 or 0.005 in.). Using the ratchet, the micrometer shall be again closed so slowly on the calibrating device that the mil scale divisions may be easily counted as they move past the reference mark, or at the rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, when the reading shall be taken.

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[1] This thickness apparatus and procedure is the same as that used for the testing of mica as described in Sections 6 to 11 of the Tentative Method of Test for Grading Natural Mica According to Size Commercial Quality, and Thickness (A.S.T.M. Designation: D 351 - 32 T), see p. 907.

Procedure in Calibrating Method B Instruments.

(*c*) The manipulative procedure for calibrating instruments used in *Method B* shall be in accordance with the following:

The micrometer shall be slowly closed on the gage or calibrating device until contact of the surfaces and gage is made. The criterion of contact is the initial development of frictional resistance to movement of the gage device between the micrometer surfaces.

Flatness of Micrometer Surfaces.

(*d*) The anvil and spindle surfaces of the micrometer shall be flat to within 0.00005 in. The flatness may be determined by use of an optical flat, as follows:

After cleaning the surfaces of the flat and the micrometer (Paragraph (*a*)) the latter shall be closed on the flat as described in Paragraph (*b*) or (*c*). When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The location, shape and number of these bands indicates the deviation from flatness in increments of half the average of the wave lengths of white light, which is taken as 0.00001 in.

A *flat surface* forms straight, parallel and equidistant fringes.

A *grooved surface* forms straight parallel fringes at unequal intervals. The estimated maximum displacement of any line from its normal position, where all lines would be equidistant, is a measure of deviation from flatness.

A *symmetrical concave or convex surface* forms concentric circular fringes, and their number is a measure of deviation from flatness.

An *unsymmetrical concave or convex surface* forms a series of curved fringes, cutting the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the termini of any fringe is a measure of the deviation from flatness.

Parallelism of Micrometer Surfaces.

(*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to within 0.0001 in. when tested with a pair of screw-thread-pitch wires whose diameters, accurate to 0.00002 in., differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils in the 1-in. micrometer). The micrometer shall be closed on the wire according to the procedure described in Paragraph (*b*) or (*c*). Observations, made with either wire placed at any location between the surfaces shall show differences of less than 0.0001 in.

Zero Reading.

(*f*) The position of the anvil shall be such that a zero reading is obtained when the micrometer is closed on the anvil as described in Paragraph (*b*) or (*c*). Ten trials shall give ten readings of zero.

Wear of Micrometer Screw. (*g*) The device for compensating for wear of the micrometer screw shall be adjusted so that the spindle has no perceptible lateral or longitudinal looseness and yet may be rotated with a torque load of not more than $\frac{1}{4}$ in.-oz.

Micrometer Screw Error. (*h*) The micrometer screw error, after zero adjustment is made, shall be checked at 2, 5, and 10 mils, and at intervals of 100 mils over the remaining graduated scale. For checks up to and including a thickness of 10 mils, selected gage blades the thicknesses of which are known to ±0.00002 in. shall be used. Checks at values greater than 10 mils shall be made with standard gage blocks. Three times the standard deviation for ten readings at each setting shall not exceed 0.1 mil (0.0001 in.). Manipulation of the instrument in these checks shall be in accordance with Paragraph (*b*) or (*c*).

Ratchet Pressure. (*i*) The ratchet shall be so adjusted that a pressure of not more than 27 nor less than 23 lb. per sq. in. is developed when the spindle surface is contacted with a polished steel surface as described in Paragraph (*b*).

Specimens. 10. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Method A:

Method A. 11. Method A is suitable for determining the thickness of papers which must be held to very close tolerances. The instrument used shall conform to the requirements specified in Section 8 (*a*).

Before starting measurements of thickness the micrometer shall be closed on the specimen at a location outside the area to be measured. The micrometer shall then be opened not more than 4 or 5 mils (0.004 or 0.005 in.) and then moved into the area selected for measurement. Using the ratchet, the micrometer surfaces shall be closed so slowly on the specimen that the mil scale divisions may be easily counted as they move past the reference mark, or at a rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, and then the thickness shall be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

Method B:

Method B. 12. Thickness measurements on papers, the acceptable tolerances of which may be wider than those requiring the use of Method A, shall be made according to Method B, as follows:

In the determination of thickness the micrometer specified in Section 8 (*b*) shall be slowly closed on the specimen until contact is made, without appreciable distortion of the specimen. The criterion of contact is the initial development of frictional resistance to movement of the specimen between the micrometer surfaces. The thickness shall then be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

Report. 13. The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

TENSILE BREAKING STRENGTH

Apparatus. 14. (*a*) A testing machine of the dead-weight pendulum type suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimens. 15. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 16. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 17. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine direction and the cross-machine direction.

TEARING STRENGTH

Apparatus. 18. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp.

Specimen. 19. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample.

Method. 20. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. The specimens shall be so arranged that an equal number of tears originating from opposite edges of the specimens will be produced. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn.

Report. 21. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams.

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

BURSTING STRENGTH

Apparatus. 22. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable.

Specimen. 23. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 24. Ten bursts shall be made, five with one side of the paper uppermost and five with the other side uppermost. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 25. The report shall include the average, the maximum, and the minimum results obtained.

ABSORPTION

(RISE OF WATER)

Apparatus. 26. A suitable container and support for specimens and scale is shown in Fig. 1.

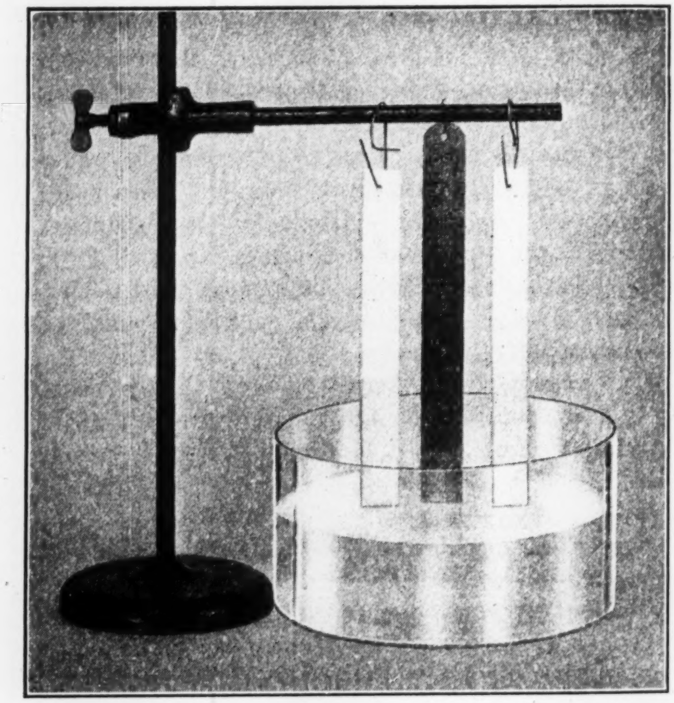

FIG. 1.—Apparatus for Absorption Test.

Specimens. 27. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

Procedure. 28. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

Report. 29. The rise of water shall be reported in millimeters to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in.

MIL WEIGHT PER REAM
(APPARENT DENSITY)

Apparatus. 30. A scale, sharp knife, chemical balance and weighing bottle are necessary for the test.

Specimens. 31. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

Procedure. 32. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size, for example, 232.3 sq. cm. (36 sq. in.) in area, and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground glass stopper before being removed from the conditioned atmosphere. The thickness of each specimen shall be determined in accordance with Sections 8 to 13.

(*b*) *Mil Weight per Ream of Any Size.*—The mil (or point) weight in pounds per ream of any size may be calculated from the following formula:

$$W = 0.002205 \frac{mSN}{ta}$$

where m = the weight of the specimen expressed in grams;

t = the average thickness of the specimen expressed in mils (thousandths of an inch);

a = the area of the specimen expressed in square inches;

S = the area of one sheet in the basic ream expressed in square inches;

N = the number of sheets in the ream.

NOTE.—0.002205 is contracted from 0.00220462.

NOTE.—The following formulas may be used to calculate the mil weight in pounds per ream for reams of particular sizes, provided a specimen of exactly 232.3 sq. cm. (36 sq. in.) is used:

Ream of 24 by 36 in., 480 sheets.

$$W = 25.40 \frac{m}{t}$$

where m = the weight of specimen expressed in grams;

t = the average thickness of the specimen in mils (thousandths of an inch).

25.40 is contracted from 25.3972224.

Ream of 24 by 36 in., 500 sheets.

$$W = 26.45 \frac{m}{t}$$

where m and t are the same as above and 26.45 is contracted from 26.45544.

NOTE.—The ream weight may be obtained from the above formulas by omitting the thickness "t".

(*c*) *Weight per Unit Volume.*—The weight in pounds per cubic foot (density) may be calculated from the following formula:

$$D = 3810 \frac{m}{ta}$$

where m = the weight of the specimen expressed in grams.
t = the average thickness of the specimen expressed in mils (thousandths of an inch).
a = the area of the specimen expressed in square inches.

NOTE.—3810 is contracted from 3809.58336.

NOTE.—To convert weight in pounds per cubic foot to mil weight in pounds per ream of 24 by 36 in., 480 sheets, multiply by 0.24; to convert to mil weight in pounds per ream of 24 by 36 in., 500 sheets, multiply by 0.25.

Roport. 33. The weight in pounds per cubic foot or the mil weight per ream shall be reported. The size of the ream must be given when the mil weight per ream is reported.

AIR RESISTANCE

Apparatus. 34. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aperture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 ml. and shall have a total range of 350 ml. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. ± 0.5 g. (20 oz. ± 0.018 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area. When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen.

35. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken in accordance with Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure.

36. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the lubricating oil. The time required for the displacement of a certain amount of air shall be noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of lubricating oil shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 ml. (6.1 cu. in.) of air through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tinfoil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 ml. in five hours.

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Oil is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement.

Report.

37. The report shall include the following:

(*a*) the number of seconds required for the displacement of 100 ml. (6.1 cu. in.) of air;

(*b*) the area of paper through which the air was displaced;

(*c*) the thickness of the paper as obtained under Sections 8 to 13;

(*d*) the room temperature.

NOTE.—The following values show the probable accuracy obtainable in the air-resistance tests:

AIR RESISTANCE	ACCURACY
40 seconds	± 5 per cent
100 seconds	± 6 per cent
200 seconds	± 8 per cent
300 seconds	± 10 per cent

ASH

Apparatus. 38. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test.

Specimen. 39. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used.

Procedure. 40. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample.

Report. 41. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)).

ACIDITY OR ALKALINITY

Apparatus. 42. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-ml. glass burette graduated to 0.1 ml., 250-ml. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid-resistant and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 2). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 ml. of c.p. ethyl alcohol.

43. From the original samples obtained in accordance with Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided. **Sample.**

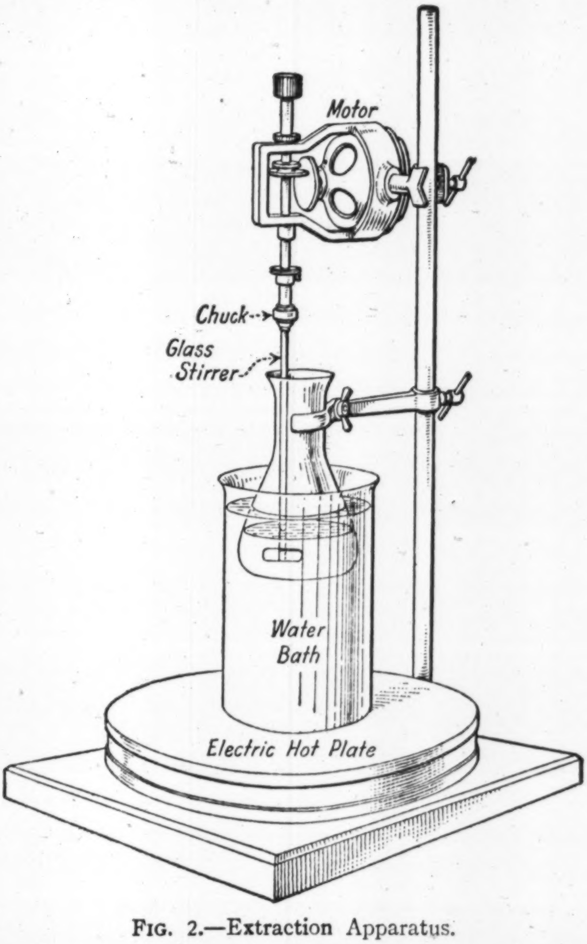

FIG. 2.—Extraction Apparatus.

44. (*a*) *Extraction.*—One gram of the composite sample shall be placed in a 250-ml. Erlenmeyer flask and 100 ml. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the **Procedure.**

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[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action. The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[1]

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-ml. Erlenmeyer flask without washing.

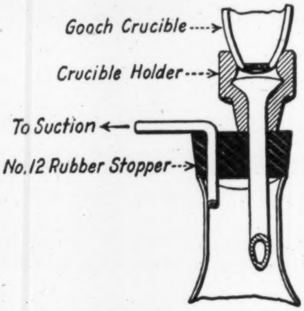

FIG. 3.—Filtration Apparatus.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-ml. porcelain Gooch crucible and holder assembly, like that shown in Fig. 3. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

NOTE.—To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified condi-

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[1] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C. within the flask during extraction, should prove satisfactory.

tions. The result should check with the curve shown in Fig. 4. This curve will be found valuable as a check on the purity of the distilled water used, although its chief purpose is to indicate the proper blank correction to be applied to the titration.

The number of milliliters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

Report.

45. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made in either of two ways:

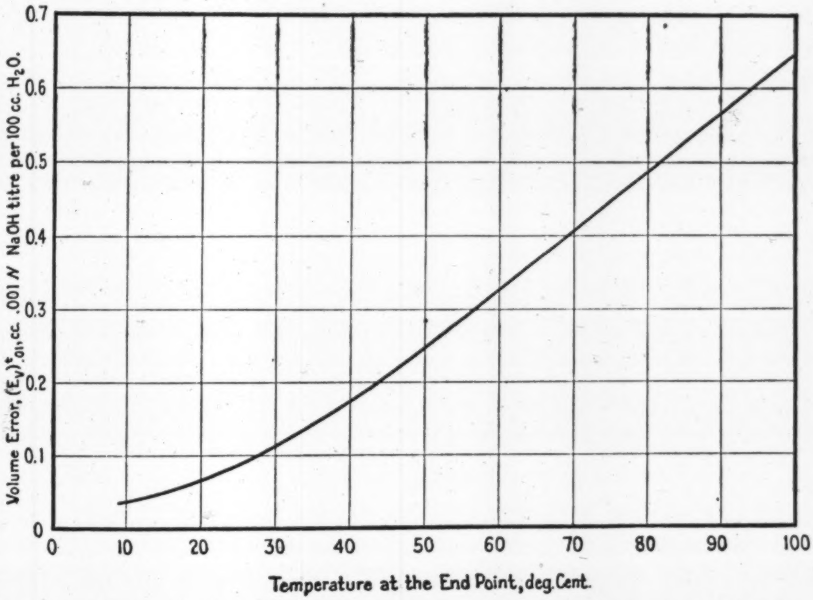

Fig. 4.—Showing Titration Error Due to Volume and Temperature of Water in a Solution at its End-Point.

If $(E_v)\frac{t}{N}$ represents the volume error of a solution where t and V are the temperature and volume at the end-point of a titration, and $N =$ the normality of the titer, then it is calculated as follows:

$$(E_v)\frac{t}{N} = (E_v)^t 0.01 \times \frac{0.01}{N} \times \frac{V}{100}$$

(*1*) By running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point;

(*2*) By calculating the blank error with the aid of the curve shown in Fig. 4.

Note.—The second method is the more convenient and probably more reliable. This curve shows the number of milliliters of 0.01 N NaOH solution required to produce an end-point at various temperatures in 100 ml. of distilled water, using **5 drops of the specified indicator. Correction by the use of this curve is valid only**

if the solution has been boiled and titrated at elevated temperatures to insure absence of dissolved CO_2.

This correction is the number of milliliters of titer solution (volume error) corresponding to the point on the curve determined by the temperature and volume of the solution at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline the correction shall be added.

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters titer}\\ \text{solution (corrected)}\end{matrix}\right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Percentage acidity (or alkalinity)} = \left\{\begin{matrix}\text{milliliters}\\ \text{titer (corrected)}\end{matrix}\right\} \times \text{normality} \times 4.$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926,[1] information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

SURVEY FOR CONDUCTING PATHS

Scope. 46. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 47 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials.[2]

Apparatus. 47. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 461 (1926).

[2] See p. 811.

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

Specimens. 48. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)).

Procedure. 49. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used.

NOTE 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

NOTE 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper appears in the Appendix.

Report. 50. The report shall include the following:

(*a*) The total number of conducting paths and the conducting paths per unit area.

(*b*) The length, width, area, and thickness of the specimen.

(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.

(*d*) The speed of the paper.

DETERIORATION

Apparatus. 51. (*a*) *Baking Oven.*—An electrically-heated oven, equipped with an efficient means of circulating air *within* or *through* the heated chamber, and a suitable fixture upon which the paper specimens may be mounted, shall be used. In case the air is circulated *within* the body of the oven, for example by fan, it is required that the fixture upon which the specimens are mounted be a turntable rotating within the oven at a speed of about 20 r.p.m., so that the specimens shall be uniformly exposed to the oven conditions. In the case of heated air circulating *through* the oven, the fixture holding the specimens may be stationary but it is essential that it shall be mounted so as to be at least 4 in. from the oven walls at any point to permit adequate circulation in all parts of the oven, and the design should be such that there shall be an air velocity of at least one foot per second through the oven.

(*b*) *Testing Equipment.*—In addition to the oven it is necessary to provide testing machines for making physical measurements on the baked specimens. The tests may be tensile breaking strength, tearing strength, folding endurance, or brittleness.[1]

Specimens. 52. (*a*) The specimens shall be at least $\frac{1}{2}$ in. in width and at least 12 in. in length, and shall be cut from samples obtained in accordance with Section 2 (*a*). At least five groups of 5 specimens each shall be selected for each type of physical test noted in Section 51 (*b*). These groups of specimens shall be selected from the gross sample in some rational manner, so as to represent any known or suspected differences in the quality of the product.

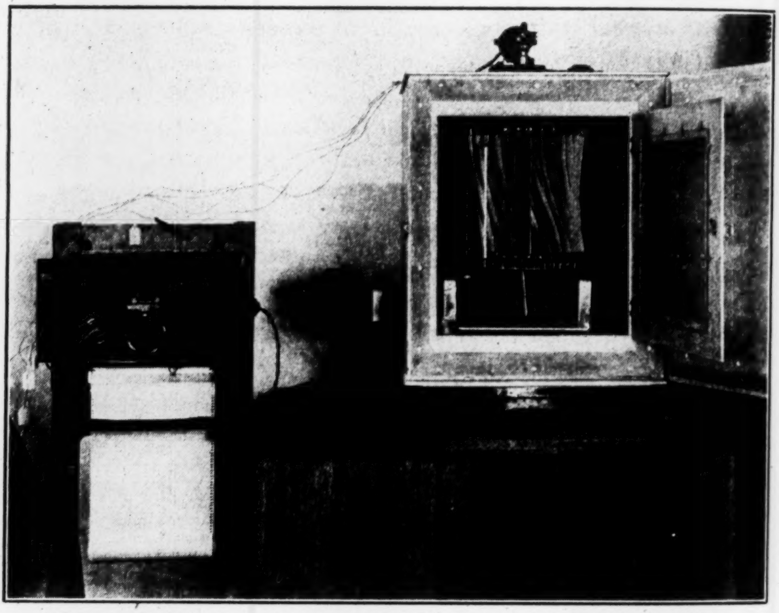

FIG. 5.—Baking Oven Equipped for Circulating Air Within the Oven.

Baking. 53. (*a*) The specimens shall be mounted on the fixture as shown in Figs. 5 and 6. In the case of the rotating turntable, Fig. 5, the specimens shall be mounted at such an angle that they will assist, fan-like, in stirring the air within the oven. In the case of a stationary scheme of mounting, Fig. 6, the specimens shall be mounted vertically. The rows of clips supporting the specimens, top and bottom, should be set alternately at 45-deg. angles across the oven so that the air flowing horizontally through the oven would pass between these staggered rows, turbine fashion, and assist in keeping the temperature uniform in all parts of the oven.

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[1] The test for folding endurance does not appear in these methods but will be included as soon as the test is developed by the committee. Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

The fixture, readily removable from the oven for mounting the specimens, shall be put in place, and the oven, previously brought to 135° C., shall be closed. Air shall be circulated, as previously indicated, and the temperature shall be maintained at 135° C. ± 2° C. for 96 hours.[1] It is imperative that the differences in temperature in different parts of the oven shall not exceed 2° C.

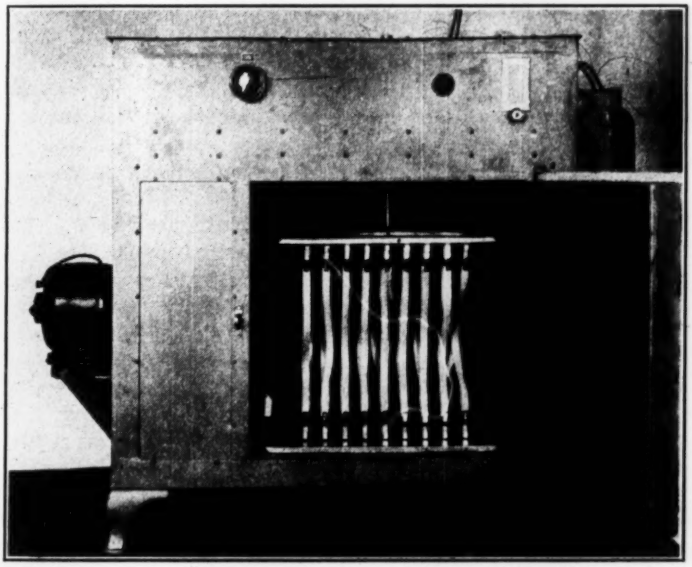

FIG. 6.—Baking Oven Equipped for Circulating Air Through the Oven.

Conditioning and Testing.

54. The baked specimens shall be removed from the mounting fixture, care being taken not to damage the strips, and shall be conditioned in a humidity room at 60 to 65 per cent relative humidity and at a temperature of 68 to 86° F., for a period of 4 hours. They shall then be tested in this conditioned room for tensile breaking strength, tearing strength, folding endurance, or brittleness.[2]

Report.

55. The maximum, minimum and average values shall be reported for each type of test used.

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[1] These temperature and time conditions are satisfactory for the more stable types of cable insulating papers. Less severe conditions should be used for other insulating papers and these will be included as soon as they are developed by the committee.

[2] The test for folding endurance does not appear in these methods but will be included as soon as the test is developed by the committee. Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

APPENDIX

DESCRIPTION OF APPARATUS FOR A SURVEY FOR CONDUCTING PATHS IN UNTREATED INSULATING PAPERS

Equipment and procedure which have been found to be suitable for making the survey of conducting paths for different thicknesses of paper are as follows:

For Paper Having a Thickness of 0.038 mm. (0.0015 in.) or Under.—For paper having a thickness of 0.038 mm. (0.0015 in.) or under, a brass plate, a brass roller with an insulated handle, a pair of telephone receivers having a total resistance of 3000 ohms, a resistor of 80,000 ohms, and a source of direct voltage of 110 volts is used in this test. The brass plate is 31.8 cm. (12.5 in.) in width and 38.7 cm. (15.25 in.) in length and is machined and polished until its surface is level and smooth. The brass roller has a diameter of 5.08 cm. (2 in.) and a face of 2.54 cm. (1.00 in.) in width. The surface of the roller should be accurately cylindrical and polished so that it will always make a line contact when it is rolled over the brass plate in any direction. A brass plate which will warp the least is best obtained by casting a plate at least 2.54 cm. (1.00 in.) in thickness and dressing down the surface to the desired smoothness.

The size of the specimen is 38.7 cm. (15.25 in.) square, and is prepared for test as follows: Using a soft pencil (No. 2) and bearing lightly, mark off 12 swaths on each specimen (see Fig. 1). Each swath is 2.54 cm. (1 in.) in width and 30 cm. (12 in.) in length. The swaths are spaced 0.63 cm. (0.25 in.) from each other. The specimen is then placed on the brass plate in such a manner that the ends of all the swaths are spaced 0.63 cm. (0.25 in.) from the edges of the brass plate. The specimen may be held in position by means of two weights as shown in Fig. 1.

Connect the brass roller to one pole of the 110-volt circuit. Connect the brass plate, the 80,000-ohm resistance and the telephone receivers in series to the other pole of the 110-volt circuit. (See Fig. 1.) Run the brass roller once over each swath slowly in succession and count the clicks audible in the telephone receivers. Each click is considered to represent a conducting path. The total number of clicks counted on all the specimens divided by the total area of all the swaths of all the specimens, is the number of conducting paths per unit area.

For Paper Having a Thickness Greater Than 0.038 mm. (0.0015 in.) and Less Than 0.76 mm. (0.030 in.).—For paper having a thickness greater than 0.038 mm. (0.0015 in.) and less than 0.76 mm. (0.030 in.) a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of brass rollers are used. The brass plate is 15.2 cm. (6 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. Each brass roller has a diameter of 3.81 cm. (1.5 in.) and a face 2.54 cm. (1 in.) in width. The surface of each brass roller is accurately cylindrical and polished so that it makes a line contact when it is placed in its position on the brass plate. The brass rollers are mounted in two parallel rows above the brass plate in such a manner as to permit each individual roller to be raised away from the brass plate or lowered to make a line contact with it. The rollers in each row are spaced and have a common geometric axis. The axes of the two rows of rollers are parallel to each other and also to the long edges of the brass plate. The rollers in one row are staggered with respect to the rollers in the other row so that the surface of paper passing under the first row of rollers will be partially overlapped by the second row of rollers (see Fig. 2). The entire surface of the paper makes contact with the rollers at least once and a part of the surface of the paper will make contact twice. The rollers and plate are adequately insulated from each other.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the brass plate and the brass rollers. During the test period the moisture content of the specimen shall not exceed 7 per cent. Lower the brass rollers to make contact with the specimen. Before connecting the transformer to the source of alternating voltage, connect the brass plate to one of the high-voltage terminals of the transformer, and the brass rollers, in multiple, to the other high-voltage terminal of the transformer. Then connect the low-voltage side of the transformer with its regulating equipment to the source of alternating voltage. Adjust the voltage between the brass plate and the brass rollers to the required value (100 volts per mil thickness of the specimen). Pass the specimen along between the rollers and the plate at a speed not to exceed 9.75 m. (32 ft.) per minute and count the number of holes burned in the specimen. Each hole shall be considered as representing a conducting path. The total number of holes counted in all the specimens divided by the total area covered (one side only) of all the specimens is the number of conducting paths per unit area.

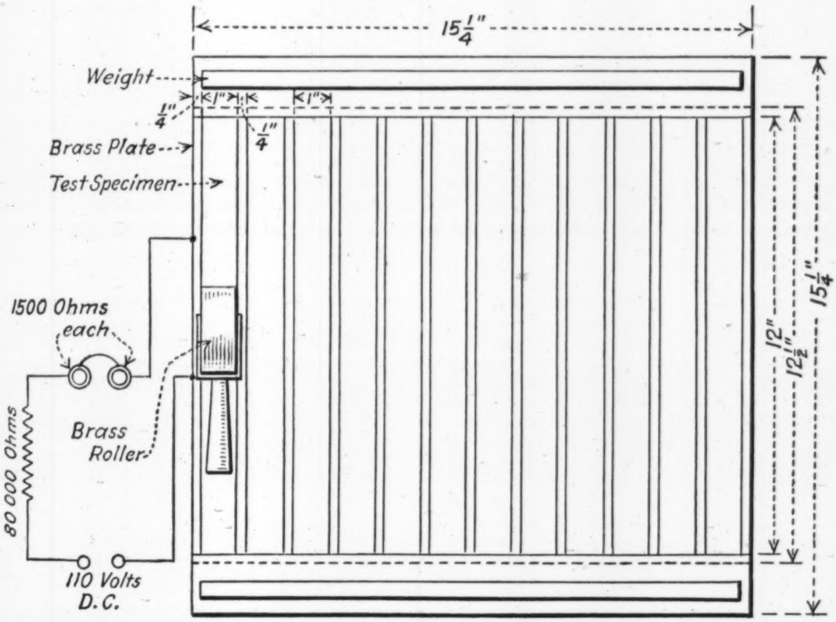


FIG. 1.—Arrangement of Apparatus for Surveying Thin Paper for Conducting Paths.

NOTE.—*Caution:* Disconnect the transformer from the source of alternating voltage before proceeding to place the next specimen between the brass plate and brass rollers.

Specimens in the form of pads of tape may be conveniently tested with an apparatus somewhat similar to the above wherein the pad is mounted on a suitable drum and the entire length of the paper in the pad rerolled on to a second drum, the paper meanwhile passing between two cylindrical rollers across which voltage is applied. The lower roller is somewhat wider than the tape and the upper roller somewhat narrower to prevent arcing through the air between the rollers. The conducting paths are counted by means of a relay and mechanical counter.

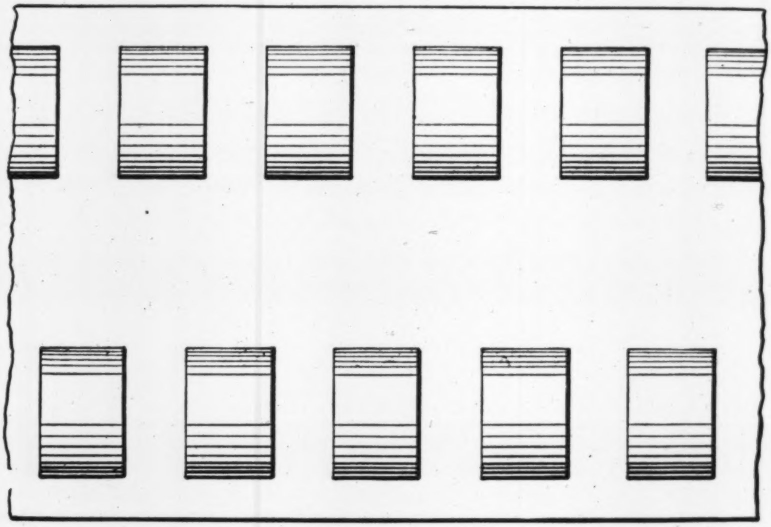
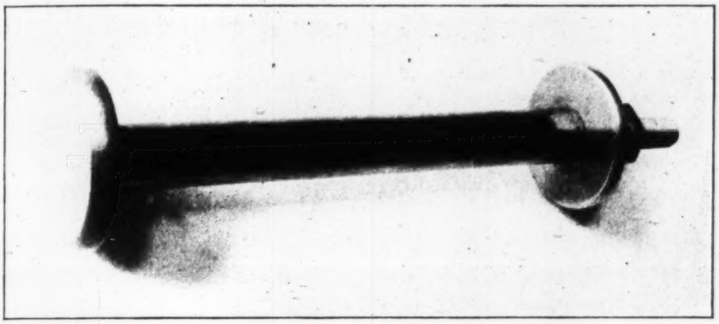


FIG. 2.—Arrangement of Brass Rollers Used in Surveying Paper for Conducting Paths.

For Paper Having a Thickness of 0.76 mm. (0.030 in.) or Over.—For paper having a thickness of 0.76 mm. (0.030 in.) or over a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of disc electrodes are used. The brass plate is 20.3 cm. (8 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. The contact surface of the disc electrodes has a diameter of 3.81 cm. (1.5 in.) with edges rounded to a curvature of 0.64 cm. (0.25 in.) radius. Figure 3 (*a*) shows a convenient design and Fig. 3 (*b*) shows the parts unassembled. The contact surface of each electrode is machined and polished until it is level and smooth and makes an accurate surface contact when it is placed in its position on the brass plate. The disk electrodes are mounted in four parallel rows above the brass plate in such a manner as to permit each individual electrode to be raised away from the brass plate or lowered to make an accurate surface contact with the plate. The four rows of electrodes are parallel to the long edges of the brass plate. The electrodes in one row are staggered with respect to the electrodes in each of the other rows so that the surface of a sheet of paper passing under the electrodes of the first row will be partially overlapped by the electrodes in the second row. Likewise, the surface of paper passing under the electrodes of the second row will be partially overlapped by the electrodes in the third row. And finally, the surface of paper passing under the electrodes of the first and third rows will be partially overlapped by the electrodes in the fourth row. When a sheet of paper has been passed under these four rows of electrodes, the entire surface of the paper will have made contact with the electrodes at least once and a part of the paper surface will have made contact twice. The electrodes and the brass plate should be adequately insulated from each other.


(*a*) Assembled.

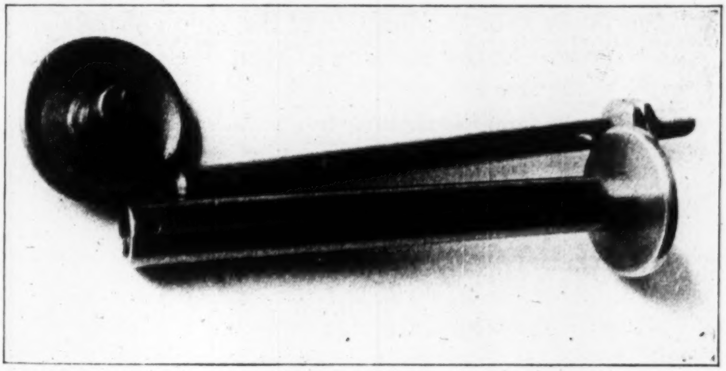

(*b*) Unassembled.

FIG. 3.—Disk Electrode for Surveying Paper Over 0.76 mm. in Thickness for Conducting Paths.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the disk electrodes and the brass plate. Lower the electrodes to make contact with the specimen, and then proceed as described above for paper 0.038 mm. (0.0015 in.) to 0.76 mm. (0.030 in.) in thickness, except that the specimen is passed between the electrodes and the brass plate at a speed not to exceed 11 m. (36 ft.) per minute. The voltage between the plate and the electrodes should be 100 volts per mil thickness of the specimen.

TENTATIVE METHODS OF TESTING LAMINATED SHEET MATERIALS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 229 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1928, 1930, 1931, 1932.

Scope. 1. These methods are intended to apply to laminated flat sheet materials to be used as electrical insulation.[2]

Definition of Terms. 2. In referring to the cutting of the specimens and the application of the load, the following definitions apply:

Flatwise.—Load applied to the face of the laminations.

Edgewise.—Load applied to the edge of the laminations.

Lengthwise.—In the direction of the length of the sheet.

Crosswise.—In the direction at right angles to the length of the sheet.

NOTE.—When the sheet has the same length and width, one dimension shall arbitrarily be designated as the length, and the other as the width.

TENSILE STRENGTH

Apparatus. 3. Any standard type of testing machine may be used. The machine shall be accurate to within 1 per cent on the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 4. Tension test specimens shall conform to the dimensions shown in Fig. 1. The surfaces of the specimen shall be smooth and free from scratches.

Procedure. 5. Five specimens cut lengthwise and five specimens cut crosswise of the sheet shall be tested.

Temperature. 6. All tests shall be made at normal room temperature of about 20° C. (68° F.).

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] Tests for shearing strength, compressive strength, moisture absorption, oil absorption and degree of curing are being studied by the committee. Various mechanical tests, particularly applicable to thin laminated sheet materials, are being developed.

Speed of Testing Machine.

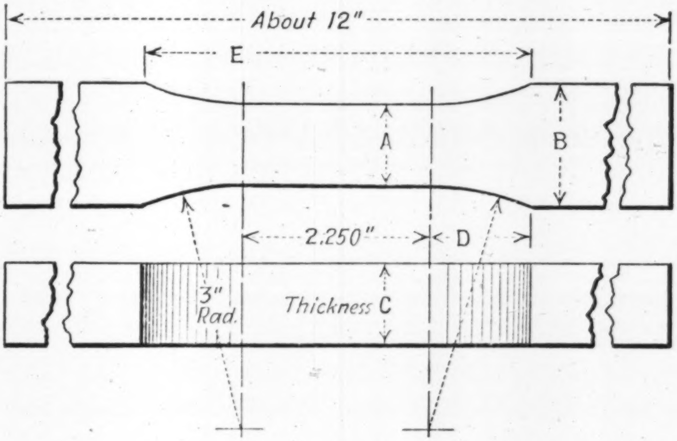
7. The cross-head speed of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

Modulus of Elasticity.

8. When it is desired to determine the elongation under load, a suitable extensometer measuring the elongation on a 2-in. gage length shall be used. The cross-head speed of the testing machine shall not exceed 0.03 in. per minute when the machine is running idle.

Procedure.

9. The total change in length between zero load and a stress of 5000 lb. per sq. in. shall be determined.



When C is less than $\frac{1}{8}$ in., A is $\frac{1}{2}$ in., B is $\frac{3}{4}$ in., D is 0.857", E is 3.964 in.
When C is $\frac{1}{8}$ in. or over, A is 1 in., B is $1\frac{1}{2}$ in., D is 1.199", E is 4.648 in.

Fig. 1.—Tension Test Specimen for Laminated Sheet Insulating Materials.

Report.

10. The report shall include the following:

(*a*) The direction in which the specimen was taken, whether lengthwise or crosswise of the sheet.

(*b*) The thickness and width of each specimen in inches or centimeters.

(*c*) The breaking load of each specimen, in pounds or kilograms.

(*d*) The tensile strength of each specimen, in pounds per square inch or in kilograms per square centimeter.

(*e*) The location and nature of the fracture.

(*f*) The elongation in inches at a stress of 5000 lb. per sq. in., if determined.

(*g*) The room temperature.

FLEXURAL STRENGTH

(FORMERLY CALLED TRANSVERSE STRENGTH)

(*A*) *For Materials $\frac{1}{32}$ in. Thick or Over*[1]

Apparatus. 11. (*a*) Any standard type of testing machine may be used. The machine shall have an accuracy of at least 1 per cent of the lowest load for which it is used.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of $\frac{1}{8}$ in. for material $\frac{1}{8}$ in. or over in thickness, and to a radius of $\frac{1}{16}$ in. for thinner materials. For material thinner than $\frac{1}{8}$ in. both supports shall be provided with a pin or other stop to align one side of the specimen perpendicular to the line of contact with the supports. The distance between the points of support shall be 4 in. for edgewise tests of all thicknesses and eight times the nominal thickness of the material to be tested for tests in the flatwise direction, except that the minimum span shall be $\frac{1}{2}$ in.

Specimen. 12. The test specimen shall be $\frac{1}{2}$ in. in width except for specimens over $\frac{1}{2}$ in. in thickness tested in the flatwise direction, which shall have the width equal to the thickness of the specimen. The thickness shall be the full thickness of the sheet. The length shall be 1 in. greater than the distance between the points of support as specified in Section 11 (*b*).

Procedure. 13. The specimens shall be tested as follows:

(*a*) Five specimens cut lengthwise of sheet, tested flatwise.
(*b*) Five specimens cut lengthwise of sheet, tested edgewise.
(*c*) Five specimens cut crosswise of sheet, tested flatwise.
(*d*) Five specimens cut crosswise of sheet, tested edgewise.

Temperature of Tests. 14. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 15. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 16. The report shall include the following:

(*a*) The directions of cutting and loading of the specimen as specified in Section 13.

(*b*) The thickness and width of each specimen in inches or millimeters.

(*c*) The breaking load of each specimen in pounds or kilograms.

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[1] Conventional flexure tests in a flatwise direction are not recommended for materials thinner than $\frac{1}{32}$ in. nor in the edgewise direction for materials thinner than $\frac{1}{8}$ in.

(*d*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter calculated from the formula:

$$S = \frac{3\ Pl}{2\ bd^2}$$

where S = maximum fiber stress;
P = breaking load in pounds or kilograms;
l = distance between supports in inches or centimeters;
b = width of specimen in inches or centimeters;
d = depth of specimen in inches or centimeters.

(*e*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus. 17. Any standard testing machine may be used provided it is accurate within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top, and the metal bearing plates shall be directly in contact with the ends of the test specimen.

Specimen. 18. (*a*) For sheets 1 in. in thickness or over, the test specimen shall be a 1-in. cube, the faces of which shall be flat and perpendicular to the axes, being ground to this condition if necessary.

(*b*) For sheets less than 1 in. in thickness, the specimen shall consist of a pile of sheets 1 in. square with a minimum number of layers to produce a height of at least 1 in.

Procedure. 19. (*a*) For sheets 1 in. in thickness or over, three specimens shall be crushed in the condition in which they are received with the load applied flatwise, three specimens with the load applied edgewise-lengthwise of the sheet and three specimens with the load applied edgewise-crosswise of the sheet.

(*b*) For sheets less than 1 in. in thickness, three specimens shall be crushed in the condition in which they are received with the load applied flatwise of the sheet.

20. The load shall be applied on the ends of the specimen and the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. (1.27 mm.) per minute when the machine is running idle. For the best results use the slowest possible speed.

Report. 21. The report shall include the following:

(*a*) The dimensions of each specimen in inches or millimeters;

(*b*) The direction of application of the load;

(*c*) The load on each specimen in pounds or kilograms at the first sign of failure;

(*d*) The ultimate compressive strength in pounds per square inch or kilograms per square millimeter, of each specimen, calculated from the area of each specimen measured before the load is applied;

(*e*) The general character of the material tested; with a description of how it acts under the applied load.

WATER ABSORPTION TESTS

Scope. 22. The water absorption tests are intended to determine the rate at which water is absorbed by the material when immersed, the total quantity absorbed at saturation, and the volatile content as received.

NOTE.—The electrical properties of different materials are not necessarily affected to the same extent by the same increase in moisture content so that the water absorption test must be correlated with the desired electrical tests.

The water immersion test and exposure to air of high humidity are not always directly comparable and should be considered before substituting one for the other.

(*A*) *Rate of Absorption*

Specimen. 23. The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches to the nearest 0.001 in. shall be measured on the original specimen at the center.

Procedure. 24. To determine the rate of absorption, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately re-weighed. The difference between the original weight and the dry weight shall be recorded as loss in weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water maintained at a temperature of 25° C. ± 2° C. (77° F. ± 3.6° F.) throughout the test. At the end of 2 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens the test shall be repeated.

Report. 25. The report shall include the values for each of the two specimens and the average values as follows:

(*a*) The thickness of the specimen before the test, to the nearest 0.001 in.;

(*b*) The percentage loss in weight on drying calculated on the original weight;

(*c*) The percentage of water absorbed in 2 hours and in 24 hours calculated on the dry weight.

(*B*) *Total Absorption at Saturation*

Specimen. 26. (*a*) The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches measured to the nearest 0.001 in. shall be measured on the original specimen at the center and on the reduced specimen in case a reduced specimen is used (see Paragraph (*b*)).

(*b*) When the sample for determining total absorption is so thick that too long a time is required for saturation using the full thickness, the thickness may be reduced as follows: The sample shall be machined to a thickness of about $\frac{5}{64}$-in., both surfaces parallel to the laminations being machined off. This may readily be done with a smooth-cut circular saw. It shall then be sanded to $\frac{1}{16}$ in. in thickness, finishing with No. 0 or finer sandpaper. While the sanded surfaces of the sample should be approximately parallel with the laminations, the thickness may vary ±0.010 in., since the object is to provide comparable specimens which will reach saturation in a reasonable time. The machined and sanded sample shall then be cut into specimens 3 by 1 in. and the edges sanded.

Procedure. 27. To determine the total water absorption at saturation, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately reweighed. The difference between the original weight and the dry weight shall be recorded as loss of weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water at a temperature of from 20 to 30° C. At the end of 24 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. The weighings shall be repeated every day for the first week and every week thereafter until the increase in weight, as shown by three consecutive weighings, averages less than 1 per cent of the total increase in weight, when the specimen shall be considered to be saturated.

(*c*) The difference between the saturated weight and that of the dry weight shall be considered as the water absorbed at saturation. The percentage of water absorbed shall be calculated on the dry weight of the specimen.

Report. 28. This report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of material, measured to the nearest 0.001 in.;

(*b*) If a reduced specimen is used, the thickness measured to the nearest 0.001 in.;

(*c*) The percentage loss in weight on drying, calculated on the original weight;

(*d*) The percentage of water absorbed at saturation, calculated on the dry weight.

(*C*) *Volatile Matter*

Specimen. 29. The test specimen shall conform to the requirements specified in Section 12.

Procedure. 30. To determine the volatile matter, two specimens shall be tested individually as follows:

The specimen shall be weighed, dried in an oven at from 105 to 110° C. until the decrease in weight as shown by two consecutive weighings at least 24 hours apart is less than 1 per cent of the total decrease in weight. The difference between the original weight and the dry weight shall be recorded as the volatile matter present in the specimen as received (this includes in addition to water any volatile solvent left during manufacture). The percentage of volatile matter shall be based on the weight of the dry specimen.

31. The report shall include the values for each of the two specimens as follows: **Report.**

(*a*) The original thickness of the material measured to the nearest 0.001 in.;

(*b*) The percentage of volatile matter, based on the weight of the dry specimen.

DIELECTRIC STRENGTH

32. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials.[1] **Dielectric Strength.**

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

33. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 – 32 T) of the American Society for Testing Materials.[2] **Dielectric Constant.**

BONDING STRENGTH

34. Any standard type of testing machine may be used, providing it is accurate within 1 per cent of the lowest load for which it is used. To this shall be fitted a head containing a 10-mm. steel ball. **Apparatus.**

35. Test specimens shall be 1 in. square, smoothly and accurately cut on a smooth saw. **Specimens.**

36. Five specimens shall be tested. These shall be placed on edge and the steel ball shall center accurately between the edges and ends of the specimen. **Procedure.**

37. All tests shall be made at normal room temperature of about 20° C. (68° F.). **Temperature.**

38. The speed of the cross-head of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle. **Speed of Testing Machine.**

39. The report shall include the following: **Report.**

(*a*) the thickness of the material; and

(*b*) the load, expressed in pounds or kilograms, required to split the specimen.

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[1] See p. 810.

[2] See p. 820.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR RESISTANCE TO IMPACT[1]

A.S.T.M. Designation: D 256 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1926; Revised, 1928, 1932.

Scope.

1. (*a*) These methods are intended to determine the relative toughness of electrical insulating materials as indicated by the energy used in breaking a standard test specimen in one blow.

(*b*) This type of impact test is made by machines of the pendulum type of which there are two kinds, the Charpy and the Izod, which differ only in the method of holding and striking the specimen. In the Charpy test the specimen is held as a simple beam (usually horizontal) and is broken by a blow delivered midway between the supports. In the Izod test the specimen is held as a cantilever beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp. The Charpy test may be made on either a plain or a notched specimen as required by the characteristics of the material tested. The Izod test requires a notched specimen in all cases.

APPARATUS

A. Simple Beam Method (Charpy Test).

Simple Beam Machine.

2. (*a*) The machine used in the simple beam method shall be of the pendulum type as shown in Fig. 1, of rigid construction and accurate to within 0.01 ft.-lb. for values of impact strength less than 1 ft-lb. and to within 1 per cent for higher values of impact strength. Accurate correction shall be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the striker (Note) is at the point of impact, that is, the center of the striking edge.

Note.—The distance from the axis of support to the center of percussion, l, may be determined experimentally from the period of oscillation of the pendulum through a small angle by means of the expression $l = 0.81 P^2$, where P is the time in seconds of a complete swing (to and fro).

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

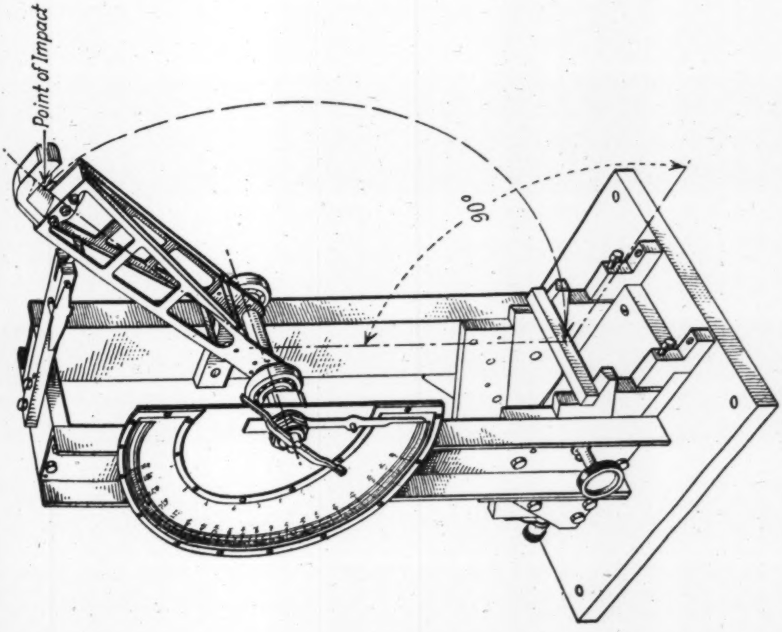
Point of Impact
90°

FIG. 1.—Simple Beam (Charpy) Impact Machine.

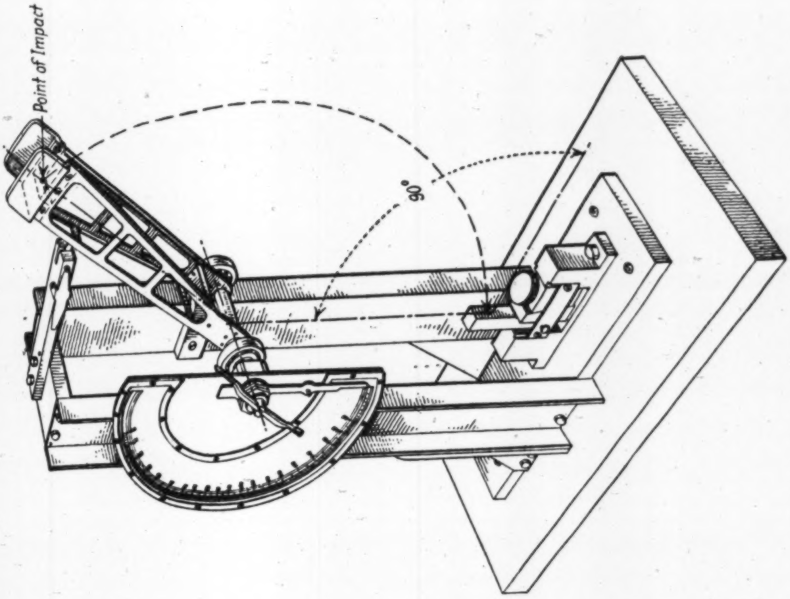
Point of Impact
90°

FIG. 2.—Cantilever Beam (Izod) Impact Machine.

(*c*) The pendulum shall be released from such a position that the linear velocity of the center of the striking edge (center of percussion) at the instant of impact shall be approximately 11 ft. per second, which is that corresponding to an initial elevation of this point of 2 ft.

(*d*) The striking edge of the pendulum shall be tapered to have an included angle of 45 deg. and shall be rounded to a radius of 0.125 in. (3.175 mm.). It shall be so aligned that in the case of rectangular specimens it will make contact across the full width of the specimen.

(*e*) The test specimen shall be supported against two rigid blocks in such a position that its center of gravity shall lie on a tangent to the arc of travel of the center of percussion of the pendulum drawn at the position of impact. The edges of the blocks shall be rounded to a radius of 0.125 in. (3.175 mm.) and the points of support shall be 4 in. (10.16 cm.) apart.

(*f*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen, and is equal to the difference between the energy in the pendulum blow and the energy remaining in the pendulum after breaking the specimen.

B. Cantilever Beam Method (Izod Test).

Cantilever Beam Machine.

3. (*a*) The machine used for the cantilever-beam method shall be of the pendulum type as shown in Fig. 2, of rigid construction and accurate to within 0.01 ft-lb. for values of impact strength less than 1 ft-lb. and to within 1 per cent for higher values of impact strength. Accurate correction shall be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the striker is at the striking edge.

(*c*) The pendulum shall be released from such a position that the linear velocity of the striking edge at the instant of impact shall be approximately 11 ft. per second, which is that corresponding to an initial elevation of the striking edge of 2 ft.

(*d*) The striking edge of the pendulum shall be an unrounded edge formed, in the position of impact, by the intersection of a plane inclined away from the specimen at an angle of 5 deg. from the vertical with another plane perpendicular to the specimen, and shall be so aligned as to make contact across the full width of the specimen. In the striking position the striking edge shall be 0.866 in. from the edge of the specimen clamp.

(*e*) Means shall be provided for clamping the specimen rigidly in position with the edges of the supporting surfaces at 90-deg. angles.

(*f*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen, and is equal to the difference between the energy in the pendulum blow and the energy remaining in the pendulum after breaking the specimen.

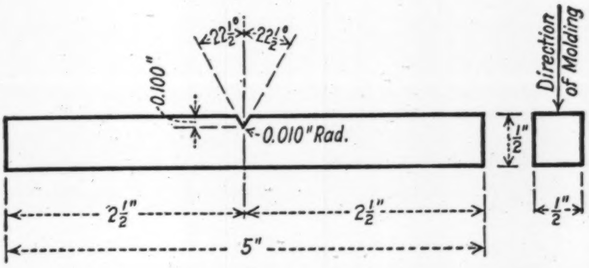

FIG. 3.—Simple Beam (Charpy) Impact Test Specimen.

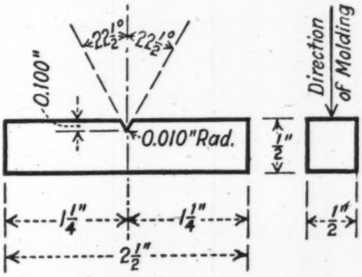

FIG. 4.—Cantilever Beam (Izod) Impact Test Specimen.

TEST SPECIMEN

A. Simple Beam Method (Charpy Test).

Charpy Test Specimen.

4. (*a*) For insulating materials other than ceramic materials the specimen shall conform to the dimensions shown in Fig. 3. The notch may be milled, filed, or molded provided the bottom of the resulting notch is smooth, straight and free from scratches. Specimens of molded insulating material shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours, followed by cooling to room temperature in a desiccator. Tests shall be made at room temperature.

(*b*) For ceramic materials the specimen shall be an unnotched cylinder 6 in. (15.2 cm.) in length. The diameter shall be 0.5 in. (1.27 cm.), 0.75 in. (1.91 cm.), or 1.125 in. (2.86 cm.), whichever value is comparable to that of the finished product.

NOTE.—The type of mold used to produce test specimens has an effect on the results obtained. Cooperating laboratories should, therefore, standardize mold and testing procedure to obtain concordant results.

B. Cantilever-Beam Method (Izod Test).

Izod Test Specimen.

5. For insulating materials not including ceramic materials the specimen shall conform to the dimensions shown in Fig. 4. The notch may be milled, filed or molded provided the bottom of the notch is smooth, straight and free from scratches. Specimens of molded insulating material shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours, followed by cooling to room temperature in a desiccator. Tests shall be made at room temperature. Sheet materials shall be tested edgewise or flatwise, as specified (Note 1).

NOTE 1.—In referring to the cutting of the specimens of laminated sheet materials and the application of the load, the following definitions apply:

Flatwise.—Load applied to the face of the laminations.

Edgewise.—Load applied to the edge of the laminations.

NOTE 2.—The type of mold used to produce test specimens has an effect on the results obtained. Cooperating laboratories should, therefore, standardize mold and testing procedure to obtain concordant results.

METHOD

A. Simple Beam Method (Charpy Test).

Charpy Procedure.

6. (*a*) Five specimens shall be broken for each test.

(*b*) The specimen shall be supported against the steel blocks so that the blow will be struck at the center of the specimen and on the side opposite the notch for notched specimens.

B. Cantilever Beam Method (Izod Test).

Izod Procedure.

7. (*a*) Five specimens shall be broken for each test.

(*b*) The specimen shall be rigidly clamped with the center line of the notch on the level of the top of the clamping surfaces (Note) and the blow shall be struck on the notched side.

NOTE.—It is recommended that a template be used to locate the specimen in the jaws as specified.

REPORT

Report.

9. The report of the test shall include the following:

(*a*) A statement indicating the type of test, the specimen used and for sheet materials the direction of testing.

(*b*) The value of the energy absorbed in breaking each specimen, expressed in foot-pounds.

(*c*) The average of the values given in Paragraph (*b*).

TENTATIVE METHODS OF TEST
FOR
RESISTIVITY OF INSULATING MATERIALS[1]

A.S.T.M. Designation: D 257 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1929, 1932.

Scope.

1. These methods cover the determination of surface resistivity and volume resistivity of both solid and liquid insulating materials.

DEFINITIONS

Definitions.

2. (*a*) *Insulation Resistance.*—The insulation resistance between two electrodes which are fastened to or imbedded in a solid insulating material, or immersed in a liquid insulating material, is the ratio of the voltage applied to the electrodes to the total current which flows between the electrodes.

(*b*) *Volume Resistance.*—The volume resistance between two electrodes is the ratio of the electromotive force applied to the electrodes, to the current which flows through the volume of the insulating material.

(*c*) *Volume Resistivity.*—The volume resistivity is the resistance between two electrodes which cover opposite faces of a centimeter cube provided there is no surface layer or that the resistance of the surface layer is so high that no appreciable part of the current flows through it.

(*d*) *Surface Resistance.*—The surface resistance between two electrodes is the ratio of the electromotive force applied to the electrodes, to the current which flows through the surface layers.

(*e*) *Surface Resistivity.*—Surface resistivity is four times the resistance between two electrodes covering opposite faces of a cube when the volume resistance is so high that practically all of the current flows through the surface layers. This is equivalent to defining surface resistivity as the resistance between two opposite edges of a square of the surface layers.

NOTE 1.—(Applicable particularly to solids).—In the definition of Insulation Resistance, the total current may consist of two parts, that which flows through a surface layer, and that which flows through the volume of the material. The surface layer is any layer on the surface of an insulator in which the resistivity is different from that of the body of the material. The most common cause of such a layer is moisture which has been deposited on the material from the surrounding air. Insulating materials may be divided into three classes with respect to deposited moisture:

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[1] **Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.**

Class 1. Materials which are not wetted by water. In the case of such materials the deposited moisture does not spread over the surface so that there is no true surface layer. Sulfur, paraffin, and the waxes are examples of such materials.

Class 2. Materials which are wetted by water but which do not absorb it. In the case of these materials, the deposited moisture spreads over the surface forming a distinct surface layer. Examples of such materials are glass, quartz, amber, hard rubber, glazed porcelain, and slate. For many of these materials the resistivity of the water in the film is only one billionth part (10^{-9}) of the resistivity of the material. Hence, a film of water of a submicroscopic thickness which is often deposited on an insulator may conduct more current than flows through the body of the specimen.

Class 3. Materials which absorb water. With these materials, there is no true surface layer, since deposited water is absorbed into the material. If the absorption takes place slowly, there may be a gradual gradation of properties on passing from the surface to the interior. Such materials do not have a true surface layer, since the change in resistivity is continuous. Examples of these materials are wood, paper, unglazed porcelain, and many molded and laminated compounds. This class includes a large part of the commercial insulating materials.

NOTE 2.—The definitions of Surface Resistance and Surface Resistivity are ordinarily applicable only to solid insulating materials.

NOTE 3.—In the definitions of Insulation Resistance, Volume Resistance and Surface Resistance, the resistances are defined in terms of the current which is not a constant but depends on the time that the circuit has been closed. After the circuit is closed, the current often changes quite rapidly. Theoretically, the current should not be read until it has become stationary. As this sometimes requires several hours, it is customary wherever possible to read the current one minute after closing the circuit. The resistance is usually computed from the value of the current at the end of one minute.

TEST SPECIMEN AND TYPE OF ELECTRODES

A. For Solid Insulating Materials

Test Specimen.

3. The test specimen for solid insulating materials shall be either in the form of a flat plate or a tube.

Material for Electrodes.

4. The material of the electrode is unimportant so long as good contact is made between the electrode and the insulating material. For a flat plate, mercury electrodes are very satisfactory though solid metal electrodes are often more convenient, and are satisfactory provided they make good contact. A metal spray or a highly conducting paint may be used. The conducting paint shall be chemically inert toward the insulating material and shall not be used on a material so porous or absorbent that appreciable penetration of the material by the conducting paint will take place.

NOTE.—Two suitable conducting paints are as follows:

Collodial Graphite Suspended in Distilled Water.—The paint should have a consistency suitable for application with a camel-hair brush. The applied paint shall be dried for at least one hour in the open air.

Nitrocellulose Lacquer Containing Graphite.—Equal proportions of lacquer and thinner shall be thoroughly mixed. To this mixture should be added graphite powder until a consistency is obtained which will barely flow from a soft brush. Enough paint should be prepared for immediate use only.

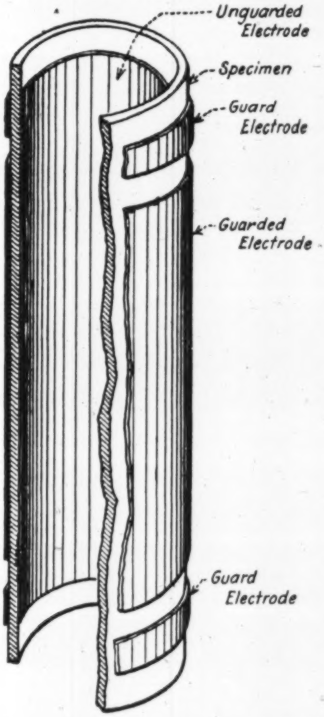

Unguarded Electrode
Specimen
Guard Electrode
Guarded Electrode
Guard Electrode

FIG. 1.—Application of Electrodes to Solid Tube Specimens.

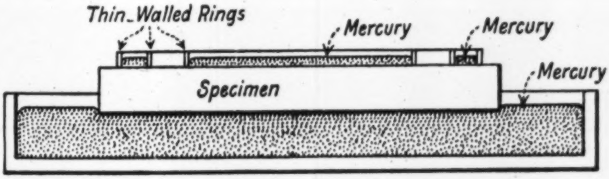

Thin-Walled Rings
Mercury
Mercury
Mercury
Specimen

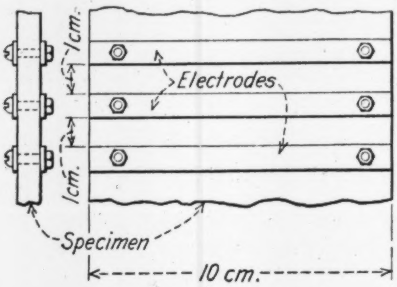
FIG. 2.—Application of Electrodes to Flat, Solid Specimens.

Electrodes.

5. *Measuring Volume Resistance.*—When volume resistance is to be measured, there shall usually be applied to each specimen three electrodes designated as the unguarded electrode, the guarded electrode, and the guard electrode. The method of applying these by means of a paint or spray to a tube is shown in Fig. 1. In the case of a tube specimen, the guard electrode shall be in two parts, one at

each end of the tube. In the case of a flat specimen, the guard electrode shall be in the form of a ring surrounding the guarded electrode as shown in Fig. 2. In any case, the distance between the guarded electrode and the guard electrode shall be uniform. If the surface resistance is high relative to the volume resistance, the guard electrode may be omitted.

6. (*a*) *Measuring Surface Resistance.*—If the volume resistance is high relative to the surface resistance, metal strips may be used as electrodes on flat plates in measuring surface resistance. One method of mounting these is shown in Fig. 3.



Note: The Electrodes are either Tin Foil or other Conducting Material applied to Both Sides of the Specimen. In the Case of Tin Foil, it is wrapped around Metal Bars. After the Bars have been mounted in Position, the Tin Foil is pressed down with a thin Tool along the Edge of the Bar to assure Intimate Contact with the Insulation. The Suggested Dimensions have been found Convenient.

FIG. 3.—Application of Electrodes for Measuring Surface Resistance of Flat, Solid Specimens.

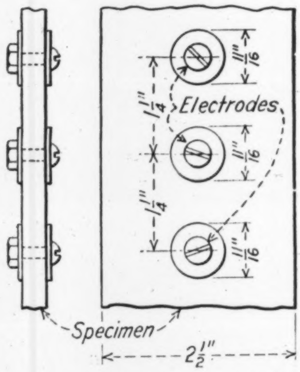


FIG. 4.—Application of Electrodes for Measuring Insulation Resistance of Flat, Solid Specimens.

(*b*) When an insulating material is intended for a specific application, it is desirable to apply test electrodes which closely resemble those in actual service. In this case it may not be possible nor desirable to separate the insulation resistance into volume resistance and surface resistance. Figure 4 shows a set of electrodes which have been found suitable for materials intended for mounting binding posts.

B. For Liquid Insulating Materials

Sampling. 7. Samples of oil shall be obtained as described in Sections 2 to 7 of the Standard Methods of Testing Electrical Insulating Oils (A.S.T.M. Designation: D 117) of the American Society for Testing Materials.[1] Samples of other liquid dielectrics shall be obtained in a similar manner with regard to cleanliness of containers and sampling apparatus and shall be representative of the lot to be tested. The quantity of the sample depends upon the type of resistivity cell used, but in any case it shall be sufficient to permit three separate resistivity determinations.

Electrodes. 8. Suitable electrodes for liquid insulating material are parallel planes, concentric cylinders, or coaxial cones. The distance between the electrodes shall not be less than 0.75 mm. (0.03 in.) nor more than 5 mm. (0.2 in.). The voltage gradient shall not exceed 200 volts per millimeter (5 volts per mil). The area of the electrodes shall be sufficiently large so that the current flow can be measured, with the apparatus available, to an accuracy of 5 per cent.

NOTE 1.—Electrode areas of 50 to 500 sq. cm. (7.7 to 77.5 sq. in.) should prove suitable.

NOTE 2.—Because of the catalytic action of some metals on oils, the electrodes shall be nickel, gold or platinum-plated.

APPARATUS

Apparatus. 9. (*a*) The apparatus shall consist of a source of constant potential, a galvanometer with suitable shunts, a calibrating resistance, reversing switches and keys, and, if very high resistances are to be measured, a condenser. The apparatus shall conform to the requirements specified in Paragraphs (*b*) to (*f*):

(*b*) *Constant Potential.*—A dry or storage battery may be used as a constant source of potential.

(*c*) *Galvanometer.*—The galvanometer shall have a high-current sensitivity and will therefore have a high resistance. A sensitivity of 10^{-10} amperes per centimeter with scale at a meter distance is desirable. The most convenient shunt is the type known as a universal shunt whereby the current through the galvanometer may be changed by powers of ten without changing its damping.

(*d*) *Calibrating Resistance.*—The calibrating resistance shall be at least 100,000 ohms and preferably 1 megohm or more.

(*e*) *Switches and Keys.*—All switches and keys shall be mounted on high-grade insulating material. Paraffin is recommended wherever it can be used.

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[1] 1931 Supplement to Book of A.S.T.M. Standards, p. 104.

(*f*) *Condenser.*—The condenser shall have a high-insulation resistance and reasonably small absorption. Its capacitance shall be greater than 0.001 microfarad and preferably greater than 0.1 microfarad. A well-insulated air or mica condenser is satisfactory.

NOTE.—The apparatus described above will measure resistances as high as 10^{14} ohms. For higher resistances there must be observed special precautions such as the elimination of the conductivity of the surrounding air. A quadrant electrometer is often employed for measuring the extremely small currents which flow through a very high resistance. A method of using such an instrument is described in U. S. Bureau of Standards *Scientific Paper No. 324,* Vol. 11, p. 364.

MEASUREMENTS

Measurements for Volume and Surface Resistance.

10. The following measurements shall be made when both volume and surface resistance are to be determined:

(*a*) Area of the guarded electrode;

(*b*) Distance between the guarded electrode and the guard electrode;

(*c*) The insulation resistance between the guarded electrode and the unguarded electrode when the guard electrode is connected to the unguarded electrode;

(*d*) The volume resistance which is the resistance between the guarded electrode and the unguarded electrode when the guard electrode is maintained at the same potential as the guarded electrode;

(*e*) The temperature of the material under test;

(*f*) The relative humidity of the surroundings.

Measurements with Special Electrodes.

11. The following measurements shall be made when the guard electrode is not used:

(*a*) Area of the electrodes;

(*b*) Distance between or spacing of the electrodes;

(*c*) The insulation resistance between the electrodes;

(*d*) Temperature;

(*e*) Relative humidity.

NOTE 1.—The resistivity of all insulating materials changes considerably with temperature. It is, therefore, essential that the temperature of the specimen at the time of the measurement be recorded.

NOTE 2.—In the case of insulating oils it is often desirable to make measurements at an elevated temperature. For trade purposes resistivity at 85° C. or 100° C. is usually quoted.

Measurements for Laminated Materials.

12. In the case of laminated materials, both the surface and volume resistivities will depend on the direction of current flow. For a complete test, the volume resistance of laminated materials shall

be measured both along and across laminations. Likewise, the surface resistance shall be measured between three sets of electrodes, one on a surface parallel to the laminations and two on a surface perpendicular to the laminations. The electrodes to be used on the surface parallel to the laminations may be disks, parallel strips, or concentric circles. The two sets of electrodes to be used on the surface perpendicular to the laminations shall be strips, the edges of one set being parallel to the laminations and the edges of the other set perpendicular to the laminations.

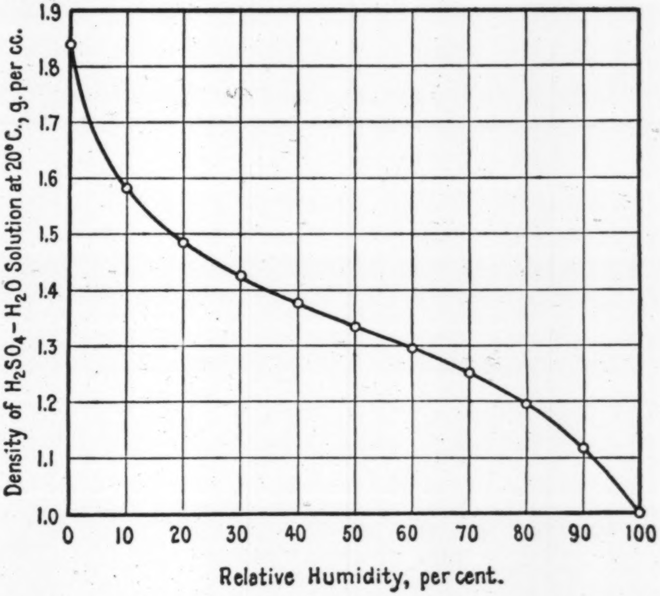

FIG. 5.—Relation of Relative Humidity of Air and Density of Acid-Water Mixture.

PROCEDURE

Humidity.

13. (*a*) Determinations of surface resistance shall be made only on specimens which have been kept for at least 48 hours in air at a definite humidity. Measurement of the insulation resistance of absorbing materials shall be made only on specimens which have been kept for 96 hours in air at a definite humidity. In either case, the specimen shall be kept undisturbed in air at this humidity during the determination. The measurements and resistivity determination shall be made without removing the specimen from the humidity chamber. For this purpose, highly insulated leads shall be passed through the walls of the chamber. This may be accomplished, even if the

humidity is very high, by cutting holes in the walls at least 2 cm. (0.80 in.) in diameter, closing them with stoppers of paraffin or sulfur, and bringing the leads out through the centers of these stoppers.

(*b*) *Humidity Control.*—The humidity may be readily maintained at any desired point by using an air-tight chamber in which a sulfuric acid - water mixture is exposed. The volume of the acid mixture shall be at least one-fiftieth of the volume of the chamber. The container for the mixture shall be an open vessel of such size that the area of the exposed liquid is at least three times as large as one side of a cube which would hold the required acid mixture. The density of the sulfuric acid - water mixture to give any desired humidity is shown by the curve in Fig. 5. No material which absorbs moisture, except those being tested, shall be allowed in the chamber. Provision shall be made for circulating the air and for maintaining the temperature constant. In case a lamp is placed inside the chamber, the specimens should be shielded from direct radiation. A desiccator may be used for a constant humidity chamber provided it can be kept where the temperature is constant.

Measurement of Resistance.

14. *Methods of Measuring Resistance.*—The resistance may be measured by means of a galvanometer used as an ammeter or if the resistances are too high to be measured directly by the use of the galvanometer, a ballistic method employing an auxiliary condenser may be used to increase the range of resistance that can be measured. The galvanometer shall have a suitable shunt for increasing its range. Figure 6 shows the diagram of connections from which it will be seen that it is only necessary to throw the switches to use it for measuring either the volume resistance or the insulation resistance of specimens of the types shown in Figs. 1 and 2.

Volume Resistance Determination.

15. The volume resistance shall be determined by either the galvanometer or ballistic method, as follows:

(*a*) *Galvanometer Method.*—With the galvanometer switch at *B*, with the guard switch at *C*, with the short-circuiting switch at *E*, and with the universal shunt set at low ratio (say 1:10,000) close the reversing switch in one direction and then close the key K_1. Increase the ratio of the universal shunt until a readable deflection is obtained on the galvanometer. Read the galvanometer deflection one minute after closing the reversing switch. Close the short-circuiting switch to *F* and leave it in this position for two minutes. Repeat measurement with the reversing switch closed in the opposite direction. If no appreciable deflection is obtained when the universal shunt ratio is 1 to 1, the resistance is too large to be measured by the galvanometer directly.

(*b*) *Ballistic Method.*—To measure very high resistances, throw the galvanometer switch shown in Fig. 6 to *A*, thus disconnecting the universal shunt. After closing the reversing switch and the key K_2 (this latter to prevent the charging current which flows into the specimen from passing through the galvanometer), close the key K_1. Open the key K_1 one minute after the reversing switch is closed. Now open key K_2. Three minutes after opening key K_1, close it again, thus discharging the condenser through the galvanometer. Read the ballistic deflection of the galvanometer. After short circuiting the specimen for two minutes, repeat the measurements with the reversing switch closed in the opposite direction. If no deflection is obtained with a leakage time of three minutes, the resistance is too high to be measured by the galvanometer.

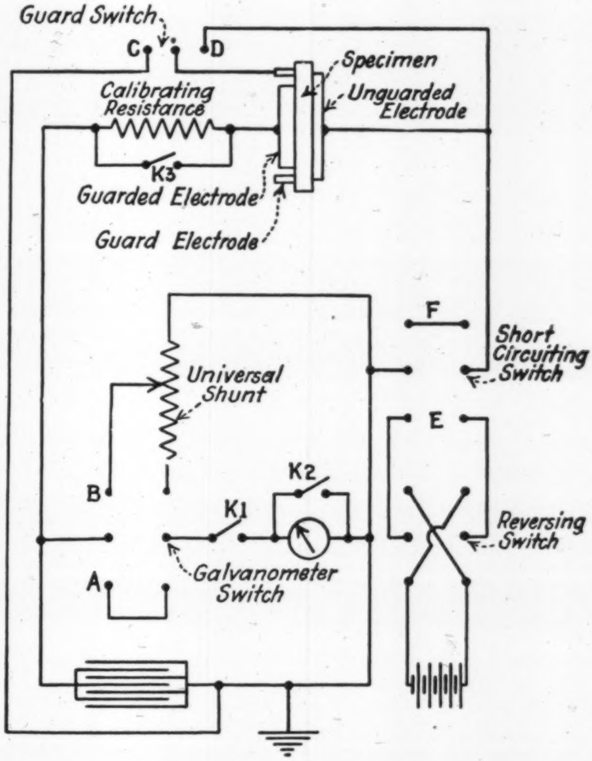
Guard Switch
C
D
Specimen
Calibrating Resistance
Unguarded Electrode
K3
Guarded Electrode
Guard Electrode
F
Short Circuiting Switch
Universal Shunt
E
K2
B
K1
Reversing Switch
Galvanometer Switch
A

FIG. 6.—Diagram of Connections for Resistivity Determinations.

Insulation Resistance Determination.

16. The insulation resistance between the guard electrode and the guarded electrode, shall be determined in accordance with the

procedure for measuring volume resistance as described in Sections 14 and 15, except that the guard switch shall be closed at D.

Precautions. 17. (*a*) *Mounting Specimens.*—In mounting the specimens for measurement, it is important that there shall be no conduction paths between the electrodes except those through the specimen. For example, the specimens shown in Figs. 3 and 4 shall be held by one or both edges so that no one of the electrodes touches the supports.

(*b*) *Measuring High Resistances.*—In measuring high resistances by the set-up shown in Fig. 6, it is important that all parts of the apparatus which are connected between the grounded sides of the battery and the guarded electrode shall be well insulated. In order to test whether the insulation is sufficient, the current through the galvanometer shall be negligible when the specimen is disconnected and the galvanometer and attached apparatus is maintained at a potential above ground, which is as high as that of this part of the circuit when the measurements of the resistance are being made. For this test, it is generally sufficient to replace the battery by a source of electromotive force having about one one-hundredth of the voltage of the battery. The ground shall then be changed to the opposite side of the battery so that it is connected to the lead going to the unguarded electrode. The circuit shall be opened at the guarded electrode. With the key K_1 closed the current through the galvanometer shall be less than 5 per cent of the current which flows through the specimen during measurement.

(*c*) *Measuring Volume Resistance.*—In measuring the volume resistance, it is important that there shall be no current flow between the guarded electrode and the guard electrode. This requires that the guarded electrode and the guard electrode shall at all times be at so nearly the same potential that the current flow between them is negligible. The exactness at which these electrodes shall be kept at the same potential will depend on the resistance between them as compared with the resistance of the specimen. In order to test this, the key K_3 shall be arranged to short circuit the calibrating resistance which is connected to the guarded electrode. With the direct deflection method, the galvanometer reading shall be the same with this key open and closed, unless the resistance of the specimen is of the same order of magnitude as the calibrating resistance.

(*d*) *High Humidity Atmosphere.*—With specimens in a high humidity atmosphere, the electrolytic action of the film of moisture at the metallic edges of the guard electrode and guarded electrode may produce an electromotive force. This will tend to send a current through the galvanometer. To test for this, it is only necessary to close the key K_1 with the galvanometer switch at B and the battery switch open. If the electromotive force is of importance, there will be a deflection of the galvanometer with the shunt set at the ratio used in making the measurement. No satisfactory readings can be made if this electromotive force gives an appreciable current. The only remedy is to use new electrodes.

CALCULATIONS

Volume Resistance.

18. If the calibrating resistance has a sufficiently high value, the resistance of a specimen, which may be measured by direct deflection, may be easily compared with the calibrating resistance. When measuring the specimen, call the shunt ratio s, and the galvanometer deflection d. Then open the guard switch and connect the guarded electrode to the unguarded electrode, thus short-circuiting the specimen. With the key K_1 closed, read the galvanometer deflection D and the shunt ratio S. Then, if the calibrating resistance has a value M, the volume resistance R, may be calculated from the formula:

$$R = M \cdot \frac{D}{d} \cdot \frac{S}{s}$$

If the calibrating resistance is so small that the battery used in the measurements will give too large a deflection of the galvanometer with the smallest shunt ratio, then it is necessary to calibrate by means of a low-voltage battery. The same measurements shall be made as in the previous case, but now it is necessary to know the voltage of the calibrating battery, E, and of the measuring battery, e. Then:

$$R = M \cdot \frac{D}{d} \cdot \frac{S}{s} \cdot \frac{e}{E}$$

When using the leakage method, the current, i, through the specimen is so nearly uniform during the time that the key K_1 is open, that the average value may be taken. Then $i = q/t$, where q is the quantity that collects on the condenser in time t. When discharged through the galvanometer, this quantity gives a ballistic deflection d. Hence, if the electromotive force of the battery is e:

$$R = \frac{e}{i} = \frac{et}{q} = \frac{et}{kd}$$

where k is the ballistic constant of the galvanometer. To determine k, a known quantity, Q, is discharged through the galvanometer. To obtain Q, a condenser of capacitance C is charged with a cell of voltage E. Then $Q = CE$. This quantity is discharged through the galvanometer giving a deflection D. It follows that:

$$k = \frac{Q}{D} = \frac{CE}{D}$$

This value of k may then be used in the above formula to determine R.

Volume Resistivity. 19. The volume resistivity, ρ, shall be calculated from the formula:

$$\rho = \frac{RA}{l}$$

where R = the volume resistance;
A = the area of the guarded electrode; and
l = average thickness of the specimen.

Theoretically, certain corrections should be made to this formula. For instance, for specimens in the form of tubes, the exact solution would consider that the lines of flow are the radii of circles. This results in a logarithmic formula for the resistivity. However, by suitable expansion, the above formula gives the first approximation which is sufficient for this work. Also, this formula assumes that the lines of flow are straight from the edge of the guarded electrode to the unguarded electrode. This is not the case but the edge correction is negligible.

Surface Resistance. 20. *Surface Resistance.*—The surface resistance is the resistance between any two electrodes in either Fig. 3 or Fig. 4, provided the volume resistance is so high that practically all the current flows through the surface film. If the insulation and volume resistance have been measured by means of either of the specimens shown in Fig. 1 or Fig. 2, then the surface resistance may be calculated from the formula:

$$\frac{1}{R'} = \frac{1}{R_s} - \frac{1}{R} \quad \text{or} \quad R' = \frac{R_s R}{R - R_s}$$

where R' = the surface resistance;
R_s = the insulation resistance; and
R = the volume resistance.

Unless R is at least 10 per cent greater than R_s, the value of R' shall be considered infinite, indicating no surface layer.

Surface Resistivity. 21. (*a*) The surface resistivity, σ, shall be calculated from the surface resistance and the size and position of the electrodes, from the following formula:

$$\sigma = \frac{R'b}{l}$$

where σ = the surface resistivity;
R' = the surface resistance;
b = the average length of the electrodes;
l = the distance between the electrodes.

(*b*) In case the electrodes are concentric circles on the same side, as in the case of the flat specimen, as shown in Fig. 2, the length b is the mean of the circumference of the guarded electrode and of the inner edge of the guard electrode.

(*c*) In the case of the cylindrical specimen shown in Fig. 1, l is the average distance between the guarded electrode and each of the guard electrodes, while b is twice the circumference of the cylinder.

(*d*) If the electrodes are strips on a flat sheet, as shown in Fig. 3, l is the distance between the strips and b their length. In this case, however, b shall be at least ten times l in order that the correction for the end of the electrodes will be so small that it may be neglected.

(*e*) In case the electrodes are disks of equal size as shown in Fig. 4, the surface resistivity may be calculated from the formula:

$$\sigma = \frac{\pi R'}{\log_e \left[\frac{d}{2r} + \sqrt{\left(\frac{d}{2r}\right)^2 - 1} \right]}$$

where d = the distance between the centers of the disks;
r = the radius of the disks.

If d has a value between $3r$ and $4r$, then the following approximate formula may be used:

$$\sigma = \frac{\pi}{2} \cdot \frac{R'(d + r)}{d - r}$$

REPORT

22. The report shall include the following: **Report.**

(*a*) The volume resistivity in ohm-cm. units;
(*b*) The surface resistivity (when determined) in ohms;
(*c*) The temperature in degrees Centigrade;
(*d*) The percentage relative humidity.

TENTATIVE METHODS OF TESTING VARNISHED CLOTHS AND VARNISHED CLOTH TAPES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 295 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1929, 1932.[2]

Scope.

1. These methods are intended to apply to varnished cloths and varnished cloth tapes to be used as electrical insulation and are directly applicable to both the "straight-cut" and "bias-cut" materials, unless otherwise stated in the method.

SAMPLING

Selecting Rolls.

2. (*a*) Shipments of varnished cloth and varnished cloth tapes shall be sampled as specified in Paragraphs (*b*) and (*c*) but no less than two rolls or pads shall be selected from any shipment. The rolls or pads shall be selected in such a manner as to be representative of the shipment.

(*b*) *Cloth.*—One roll shall be selected from each ten rolls in a shipment of full-width varnished cloth.

(*c*) *Tape.*—At least one roll or pad shall be selected from each 100 rolls or pads in a shipment of varnished cloth tape.

Selecting Samples.

3. (*a*) Not less than two turns of cloth or six turns of tape from each roll or pad selected for sampling shall be torn off and discarded before the samples are selected. The number of samples required for purposes of test shall then be cut across the entire width of each roll or pad. The length of the samples shall not be less than 91.44 cm. (36 in.) for straight-cut material; from seam to seam for sewed bias-cut material; and from jointed-selvage to jointed-selvage for seamless bias-cut material.

NOTE 1.—Specimens of bias materials cut in the above manner will exclude seams and jointed-selvages from the test areas.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] Latest revision accepted by Committee E-10 on Standards, August 11, 1932.

Note 2.—If it is desired to test the seams or jointed-selvages for tensile breaking strength, additional specimens will have to be cut so that the seams or jointed-selvages are in the center of the specimens.

(*b*) From shipments such as sheets of cloth or strips of tape, the samples shall be representative of the shipment and shall be taken in accordance with Paragraph (*a*).

CONDITIONING

Conditioning.

4. Specimens shall be conditioned before testing for at least two hours in air maintained at a temperature between the limits of 20 and 30° C. (68 and 86° F.)

THICKNESS

Apparatus.

5. A micrometer of the spring actuated, dial type shall be used. The plunger shall be capable of being raised by the application of an upward pressure to it. The plunger surface shall be circular in shape and 12.7 mm. (0.50 in.) in diameter. The anvil surface shall be plane and circular in shape, the diameter of which shall not be less than 12.7 mm. (0.50 in.). It shall be centered with respect to the plunger surface.

In addition to these requirements, the instrument shall conform to the following:

(*a*) The pressure applied to the plunger necessary to move the pointer from zero toward a positive reading shall not be greater than 1135 g. (40 oz.).

(*b*) The pressure applied to the plunger necessary to just prevent movement of the pointer from zero toward a lower reading shall not be less than 455 g. (16 oz.).

(*c*) The diameter of the dial shall be approximately 15 cm. (6 in.) and shall be graduated preferably in divisions indicating a thickness of 0.0127 mm. (0.0005 in.) and in no case greater than 0.0254 mm. (0.001 in.). Graduations indicating a thickness of 0.0254 mm. (0.001 in.) shall be at least 3 mm. (0.12 in.) apart.

(*d*) Measurements made on standard steel thickness gages shall be within the following tolerances:

Intervals	Permissible Deviation of Reading from Actual Thickness of Standard Steel Gage
0 to 0.25 mm. (0 to 0.01 in.) incl.	±0.0025 mm. (0.0001 in.)
Over 0.25 mm. to 1.02 mm. (0.01 in. to 0.04 in.) incl.	±0.0051 mm. (0.0002 in.)
Over 1.02 mm. to 3.05 mm. (0.04 in. to 0.12 in.) incl.	±0.0102 mm. (0.0004 in.)

(*e*) Convenient means shall be provided for setting the pointer to the zero position.

(*f*) The micrometer shall be tested periodically as outlined above and if it does not conform to these requirements its mechanism should be readjusted.

NOTE.—Work is now under way in Committee D-9 toward standardizing the use of the 1-in. machinist's type micrometer.

Specimens. 6. Specimens for test shall consist of samples selected in accordance with Section 3.

Procedure. 7. In making thickness measurements, only one layer of material shall be used and the micrometer plunger shall be raised to a point where its lower surface is from 0.45 to 0.55 mm. (0.018 to 0.021 in.) above the surface of the specimen lying in contact with the surface of the fixed anvil. The plunger shall be dropped from this point on to the specimen without retarding its speed of descent. When the thickness is read, care shall be taken not to touch the instrument.

Number of Measurements. 8. In the case of cloths, five readings, equally spaced across the width of the specimen, and five readings, equally spaced along the length of the specimen, shall be taken and the thickness of the cloth shall be the average of the ten measurements.

(*b*) In the case of tapes, not more than five readings shall be taken equally spaced along each specimen length and the thickness of the tape shall be the average of ten measurements taken on at least two specimen lengths.

NOTE.—The average thickness, as obtained in Section 15 for the dielectric strength test, may be conveniently used instead of the separate test described above.

Report. 9. The report shall include the average, maximum and minimum thicknesses in millimeters or inches.

TENSILE BREAKING STRENGTH

Apparatus. 10. (*a*) A testing machine[1] of the dead-weight pendulum type shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing specimens breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing specimens breaking under 22.7 kg. (50 lb.).

Test Specimens. 11. Specimens cut from the full width cloth shall be 2.54 cm. (1 in.) in width and not less than 35.54 cm. (14 in.) in length. The tape specimens shall be of the original width and shall not be less than 35.54 cm. (14 in.) in length.

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[1] This apparatus is the same as that used for the testing of paper and described in Section 14 of the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M Designation: D 202 – 32 T), see p. 842.

NOTE.—If it is desired to test the seams or jointed-selvages of bias-cut materials for tensile breaking strength, specimens obtained as described in Note 2 to Section 3 (*b*) shall be clamped in the testing machine so that the seams or jointed-selvages are midway between the two jaws. When testing, all readings obtained when the specimen breaks away from the seam or jointed-selvage shall be rejected.

Number of Specimens. 12. (*a*) In the case of straight-cut cloths, ten specimens shall be cut in the direction of the warp threads and ten in the direction of the filling threads from samples selected in accordance with Section 3.

(*b*) In the case of bias-cut cloths, ten specimens shall be cut in the direction of the length from samples selected in accordance with Section 3.

(*c*) In the case of tapes, ten specimens shall be cut from samples selected in accordance with Section 3.

Procedure. 13. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant and preferably 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the specimen breaks at or in the jaws shall be rejected.

Report. 14. (*a*) The tensile breaking strength shall be the average of the breaking loads of the ten specimens. The report shall include the average, maximum and minimum breaking loads in kilograms or pounds together with the width of the specimen and the average thickness.

(*b*) In the case of straight-cut cloths, the tensile breaking strength of the warp threads and the filling threads shall be reported separately.

DIELECTRIC STRENGTH

Method. 15. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 32 T) of the American Society for Testing Materials,[1] except that the voltage on the specimen shall in all cases be increased at the uniform rate of 0.5 kv. per second up to breakdown.

Specimens. 16. (*a*) In the case of cloths, a specimen at least 10.16 cm. (4 in.) in width shall be cut diagonally from corner to corner from a sample selected in accordance with Section 3.

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[1] See p. 810.

(*b*) In the case of tapes, the specimens shall be samples selected in accordance with Section 3.

Dielectric Strength. 17. (*a*) In the case of cloths, the dielectric strength shall be the average of the required number of puncturing voltages taken equally spaced along the specimen length.

(*b*) In the case of tapes, the dielectric strength shall be the average of the required number of puncturing voltages taken on at least two specimen lengths, one half the punctures being made equally spaced along each length.

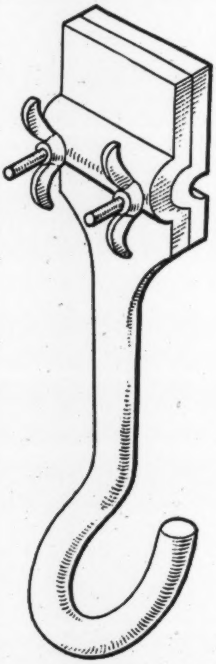

FIG. 1.—Clamp for Elongation and Deformation Test.

ELONGATION, DEFORMATION, AND THEIR EFFECT ON DIELECTRIC STRENGTH

(*In the Case of Bias-Cut Material*)

Scope. 18. (*a*) This method is intended to determine the effect of mechanical tension on bias-cut varnished cloths and tapes.

(*b*) When a bias-cut strip is weighted with a load, the length to which it will be stretched increases with time until it reaches a maximum value. The difference between this length and the original length is called the "elongation." For average material the time to reach maximum elongation is between 20 and 35 minutes.

(*c*) If the load is then removed from the strip, it decreases in length until it reaches a final elongation. The difference between this length and the original length is the amount of permanent elongation imparted to the material and is called the "deformation." For average material, the time to reach final elongation (deformation) is between 5 and 20 minutes.

NOTE.—It will be noted in the procedure for this determination (see Section 21) that the maximum time to reach elongation and deformation has been selected in each case, namely, 35 and 20 minutes, respectively.

(*d*) A characteristic feature of the test is that over the lower range of increasing loads the dielectric strength remains almost constant and the elongation and deformation are small; but as the load is increased the material stretches considerably, the elongation and deformation become large and the dielectric strength drops to a fraction of the original dielectric strength. Therefore, the load at which the dielectric strength is considerably lowered is considered the "critical load."

Apparatus.

19. The apparatus required for the test shall consist of a pair of clamps for gripping the ends of the specimen. The clamps shall not be less than 5.08 cm. (2.0 in.) in width and one shall be provided with means for attaching to a fixed support and the other with means for affixing suspended weights. See Fig. 1 for suggested form of clamp.

Specimens.

20. (*a*) In the case of bias-cut cloths, specimens shall be cut in the direction of the length from the samples selected in accordance with Section 3. They shall not exceed 3.81 cm. (1.5 in.) in width and shall be at least 91.44 cm. (36 in.) in length.

(*b*) In the case of bias-cut tapes, specimens shall be samples selected in accordance with Section 3 and they shall not exceed 3.81 cm. (1 5 in.) in width. Tapes of greater width than this shall be cut to 3.81 cm. (1.5 in.) or less before testing.

(*c*) A set of three specimens shall be used for test at each load.

Procedure.

21. (*a*) *Elongation and Deformation.*—A set of three test specimens shall be tested individually at each load, as follows: A gage length, *L*, shall be marked on the test specimen and the specimen shall be fastened between the two clamps so that the test length is centrally located between the clamps. The gage length, *L*, shall be determined from the ratio:

$$\frac{L}{W} = 10$$

where W = the width of the specimen.

The clearance distance, D, between the jaws of the clamps shall be determined from the ratio:

$$\frac{D}{W} = 22$$

The test specimen shall be weighted with a load M (including the weight of the clamp) and at the end of 35 minutes the distance between gage lines, L_1, shall be determined and the load then removed. After the load is removed the specimen decreases in length. At the end of 20 minutes after removing the load, the distance between the gage lines, L_2, shall be measured.

The percentage elongation and deformation shall be calculated from the following formulas:

$$\text{Percentage elongation} = \frac{L_1 - L}{L} \times 100;$$

$$\text{Percentage deformation} = \frac{L_2 - L}{L} \times 100$$

where L = the original gage length, in millimeters or inches;

L_1 = the distance between gage lines under load (maximum elongation), in millimeters or inches;

L_2 = the distance between gage lines after removal of the load (final elongation), in millimeters or inches.

The percentage elongation and deformation at each load shall be the average of the individual determinations made on the set of three specimens.

(*b*) *Dielectric Strength.*—After the determination of the deformation, five puncturing voltages shall be taken on the gage lengths of the set of three specimens in accordance with Method *A* for Short-Time Dielectric Strength Test as described in Sections 2 to 12 inclusive of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 32 T) of the American Society for Testing Materials.[1]

(*c*) *Thickness.*—The thickness shall be determined in accordance with Sections 5 to 9 on the set of three specimens at each puncture, and the average of the five measurements shall be considered as the thickness.

Number of Tests.

22. The determinations described in Section 21 shall be repeated on sets of three specimens at gradually increasing loads (for example, M = 2, 4, 6, 8, etc., lb. per inch of width).

Graphical Record.

23. The results shall be represented graphically on the same sheet of graph paper by plotting as ordinates the average dielectric strength

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[1] See p. 811.

in volts per mil; the percentage elongation; and the percentage deformation against the load in kilograms or pounds as abscissa.

Report. 24. The significant values which shall be reported are as follows:

(*a*) The average dielectric strength in volts per mil at each load;

(*b*) The percentage elongation at each load;

(*c*) The percentage deformation at each load.

RESISTANCE TO OIL

Scope. 25. The test for resistance to oil is a comparative test only. It is intended to give an indication of the effect of oil on the varnish film of the varnished cloth or tape. Results are determined by comparing a tested specimen with a specimen of the original material.

Specimens and Procedure. 26. Three specimens, each 15.24 cm. (6.0 in.) in length, and not exceeding 3.81 cm. (1.5 in.) in width shall be cut from the samples and immersed for 48 hours in a specified oil, maintained at a temperature of 105 to 110° C. (221 to 230° F.). At the end of this time the specimens shall be removed from the oil, allowed to cool to room temperature and wiped with a piece of dry cheesecloth.

Examination. 27. The effect of oil on the varnish film is indicated by evidence of disintegration, which may be detected by the following:

(*a*) The examination of the used oil for "turbidity."

NOTE.—The oil may be considered "turbid" if a sample of used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil when the two samples, in identical containers, are held in front of a diffused light.

(*b*) The examination of the varnish film for apparent softening or excessive tackiness.

(*c*) The partial or complete removal of the film on wiping.

Report. 28. The material shall be reported as passing the test when none of the strips show evidence of disintegration when examined in accordance with Section 27.

RESISTANCE TO PETROLATUM

Specimens and Procedure. 29. Three specimens, each 15.24 cm. (6.0 in.) in length, and not exceeding 3.81 cm. (1.5 in.) in width, shall be cut from the samples and immersed, for 15 minutes, in melted No. 5 (or better quality) petrolatum, maintained at a temperature of 150° C. (302° F.) to within ±5° C. (9° F.). At the end of this time, the specimens shall be removed from the petrolatum, wiped with a piece of dry cheesecloth and allowed to cool to room temperature.

Examination. 30. For the effect of petrolatum on the varnish film, the specimens shall be examined in accordance with Section 27 (*b*) and (*c*).

Report. 31. The results shall be reported as specified in Section 28.

WEIGHT

Weight. 32. Specimens of sufficient size to weigh not less than 5 g. (0.18 oz.) shall be accurately weighed on an analytical balance and the weight shall be reported on some commercial unit basis such as, the weight per square yard, the weight per gross yard per 1 in. in width, or the weight per roll.

THREADS PER INCH

Count. 33. The count or threads per inch of the varnished cloth or varnished cloth tape shall be determined separately on the warp and filling by counting a space of not less than 1 in. (2.54 cm.) in at least five different places in the sample strip (or strips). The average of the five determinations shall be the count.

Report. 34. The results of the warp count and the filling count shall be reported separately as threads per inch.

NOTE 1.—The warp threads in straight-cut materials are the threads which are parallel with the length dimension, while in bias-cut materials the warp threads are parallel with the seams and jointed-selvages.

NOTE 2.—Before counting black, varnished materials it will be necessary to remove the varnish film with a knife blade or other suitable instrument. Liquid varnish removers are unsuitable for this purpose as they cause a swelling of the fibers and a shrinkage of cloth with a consequent increase in threads per inch; therefore, the films must be removed mechanically.

TENTATIVE METHODS OF TESTING LAMINATED TUBES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 348 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932; REVISED, 1932.[2]

Scope. 1. These methods are intended to apply to laminated tubes to be used as electrical insulation.

TENSILE STRENGTH

Apparatus. 2. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned. Steel or brass plugs, $3\frac{1}{2}$ in. in length and of a suitable diameter with edges rounded to $\frac{1}{16}$-in. radius will be required. The plugs shall fit the specimen to within 0.010 in. They can be conveniently located in the tube by separating and supporting them on a metal rod, the lower end of which is screwed into the lower plug, and the upper end rests in a loose socket as shown in Fig. 1.

Specimens. 3. Test specimens shall be 12 in. in length. Where the wall thickness of tubing is $\frac{1}{8}$ in. or over, a lathe cut 1 in. in width and $\frac{1}{32}$ in. in depth, with corner rounded to a radius of 3 in. shall be made around the tube at the center.

Procedure. 4. Five specimens shall be tested. The inside and outside diameters shall be measured at the groove and the cross-section area shall be calculated from these dimensions. The metal plugs shall be assembled with the tube as shown in Fig. 1. This assembly shall then be grasped in the V-notched jaws of the testing machine.

Speed of Testing Machine. 5. The cross-head speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 6. The report shall include the following:

(*a*) The inside diameter of the specimen.

(*b*) The outside diameter of the specimen.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] **Revision accepted by Committee E-10 on Standards, August 11, 1932.**

(*c*) The outside diameter of the reduced section, if a groove was used.

(*d*) The full wall thickness of the specimen.

(*e*) The net area of the test section.

(*f*) The breaking load of each specimen in pounds or kilograms.

(*g*) The tensile strength of each specimen in pounds per square inch or kilograms per square centimeter.

(*h*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus. 7. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable at the top. The metal bearing plates shall be directly in contact with the ends of the test specimen.

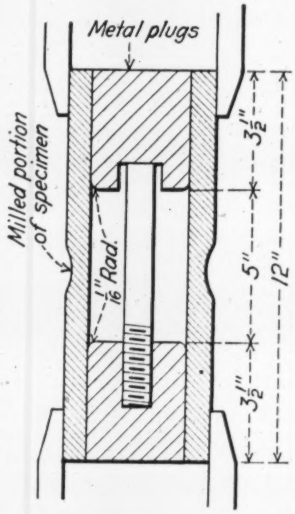

FIG. 1.—Metal Plugs Used for Tension Test, Showing Location of Plugs in Test Specimen.

Specimens. 8. Samples shall be tested as-received in specimen lengths of 1 in. Care shall be taken in cutting the specimens for the axial test to have the ends of the specimens cut accurately at right angles to the axis of the tube. Specimens which are not cut squarely are likely to give low results on test.

Procedure. 9. Five specimens shall be tested axially, with the load applied perpendicular to the faces or ends of the specimen, and five specimens shall be tested diametrically, with the load applied perpendicular to the tangent at point of application.

10. The report shall include the following: **Report.**

(*a*) The inside and outside diameters of the specimen.

(*b*) The wall thickness of the specimen.

(*c*) The direction of application of the load.

(*d*) The load on each specimen at the first sign of rupture, in pounds or kilograms.

(*e*) The ultimate compressive strength in pounds per square inch or kilograms per square centimeter, calculated from the data obtained on the application of the load perpendicular to the face of the specimen.

WATER ABSORPTION

11. Specimens for the water absorption test shall be 1 in. in length. **Specimens.** They shall be rinsed with gasoline to remove any oil from the machining operation, wiped with a dry cloth and allowed to stand in air for 2 hours to remove the gasoline.

12. (*a*) The specimen shall be dried in an oven for 1 hour at 105 **Procedure.** to 110° C. and cooled in a desiccator. For materials which will not withstand this temperature the drying shall be omitted.

(*b*) The dried specimen shall be immersed in distilled water maintained at a temperature of 25° C. ± 2° C. (77° F. ± 3.6° F.) throughout the test. At the end of 2 hours, the specimen shall be removed from the water, the surface water wiped off with a dry cloth, weighed immediately, and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours' immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours' immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens, the test shall be repeated.

13. The report shall include the following: **Report.**

(*a*) The inside and outside diameter of the specimen.

(*b*) The wall thickness of the specimen.

(*c*) The percentage of water absorbed in 2 hours and in 24 hours.

DIELECTRIC STRENGTH

Apparatus. 14. A high-voltage transformer as described in Section 2 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials,[1] shall be used. The inner electrode shall consist of a brass rod 3 in. in length with edges rounded to ¼-in. radius. This should fit snugly inside of the tube to be tested. It shall be fitted with a binding post on one end. The outer electrode shall consist of a strip of metal foil 2½ in. in width and long enough to extend around the circumference of the tube.

Specimens. 15. Specimens for the dielectric strength test shall be 12 in. in length.

Procedure. 16. Five specimens shall be tested. The brass rod inner electrode shall be placed directly in the center of the tube and for the outside electrode a strip of metal foil 2½ in. in width shall be wrapped around the tube. The tubes shall be immersed in oil and all tests shall be made at room temperature. Short-time and step-by-step tests shall be made in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials.[2]

REPORT

Report. 17. The report shall include the following:

(*a*) The inside and outside diameter of the specimen.

(*b*) The wall thickness of the specimen.

(*c*) The breakdown voltage of each specimen.

(*d*) The average breakdown voltage of all specimens.

(*e*) The average dielectric strength in volts per mil.

DENSITY

Specimens. 18. Two specimens shall be tested. Any suitable size specimen may be used. The specimen 1 in. in length used for the water absorption test, Section 11, will be found convenient.

Procedure. 19. Any suitable weight-difference apparatus for making readings in water and air, or the weight and dimensions of the specimen may be used as a basis for calculating the density.

Report. 20. The report shall express the density in c. g. s. units.

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

Phase Difference and Dielectric Constant. 21. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 – 32 T) of the American Society for Testing Materials.[3]

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[1] See p. 811.

[2] See p. 810.

[3] See p. 820.

TENTATIVE METHODS OF TESTING LAMINATED ROUND RODS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 349 – 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. These methods are intended to apply to laminated round rod materials to be used as electrical insulation.

TENSILE STRENGTH

Apparatus. 2. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 3. The specimens shall be about 12 in. in length. When the diameter of the rod is $\frac{1}{4}$ in. or over, a lathe cut 1 in. in width and $\frac{1}{32}$ in. in depth with corners rounded to a radius of 3 in. shall be made around the rod at the center.

Procedure. 4. Five specimens shall be tested.

Temperature. 5. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 6. The cross-head speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 7. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The breaking load of each specimen in pounds or kilograms.

(*c*) The tensile strength of each specimen in pounds per square inch or kilograms per square centimeter.

(*d*) The room temperature.

FLEXURAL STRENGTH

Apparatus. 8. (*a*) Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 11, 1932.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of $\frac{1}{8}$ in. The distance between the points of support shall be 4 in. when the diameter of rod is $\frac{1}{2}$ in. or over. For smaller rods the distance between supports shall be eight times the diameter of the rod. The load shall be applied through a steel block having a semi-circular contact edge of the same radius as the rod with edges rounded to a radius of $\frac{1}{8}$ in.

Specimens. 9. The specimen shall be 5 in. in length.

Procedure. 10. Five specimens shall be tested.

Report. 11. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The breaking load of each specimen in pounds or kilograms.

(*c*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter, calculated according to the following formula:

$$S = \frac{8\ WL}{d^3}$$

where S = the maximum fiber stress;
W = the breaking load in pounds or kilograms;
L = the distance between supports in inches or centimeters;
d = the diameter in inches or centimeters.

COMPRESSIVE STRENGTH

Apparatus. 12. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top. The metal-bearing plates shall be directly in contact with the ends of the test specimen.

Specimens. 13. Samples shall be tested as received in specimen lengths of 1 in. The ends shall be accurately cut or ground square with the sides.

Procedure. 14. Five specimens shall be tested with the load applied perpendicular to the faces or ends of the specimen.

Report. 15. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The load on each specimen in pounds or kilograms at the first sign of rupture.

(*c*) The ultimate compressive strength in pounds per square inch or kilograms per square centimeter calculated from the data obtained on the application of the load perpendicular to the face of the specimen.

DENSITY

16. Two specimens shall be tested. Any suitable size specimen may be used. The samples used for the compressive strength test, Section 13, will be found convenient. **Specimens.**

17. Any suitable weight-difference apparatus for making readings in water and air, or the weight and dimensions of the specimen may be used as a basis for calculating the density. **Procedure.**

18. The report shall express the density in c.g.s. units. **Report.**

TENTATIVE METHODS OF TESTING FLEXIBLE VARNISHED TUBING USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 350 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. These methods are intended to apply to flexible varnished tubings to be used as electrical insulation for leads on electrical apparatus.

SAMPLING

Sampling. 2. (*a*) A sufficient number of the pieces of tubing to total not less than 1.83 meters (6 ft.) in length shall be selected from each 305 meters (1000 ft.) in the shipment, but in no case shall less than 1.83 meters (6 ft.) be taken from a shipment and the pieces shall be selected in such a manner as to be representative of the shipment.

(*b*) The number of specimens required for purpose of tests shall be cut from the pieces selected in accordance with Paragraph (*a*) and care shall be taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

CONDITIONING

Conditioning. 3. Specimens shall be conditioned for at least 2 hours in air maintained at a temperature between the limits of 20 and 30° C. (68 and 86° F.), before testing.

DIMENSIONS

Apparatus. 4. A set of standard gage rods and a $\frac{1}{2}$-in. ratchet type hand micrometer with $\frac{3}{16}$-in. foot graduated to thousandths of an inch shall be used.

NOTE 1.—A set of three standard gage rods will be required for each size of tubing and they shall conform to the maximum, minimum and nominal dimensions of each size listed in the following table:

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 11, 1932.

A.S.T.M. STANDARD SIZES FOR FLEXIBLE VARNISHED TUBING.

Size	Inside Diameter, in. Maximum	Minimum	Nominal	Size	Inside Diameter, in. Maximum	Minimum	Nominal
1	0.299	0.289	0.294	10	0.110	0.102	0.106
2	0.268	0.258	0.263	11	0.099	0.091	0.095
3	0.239	0.229	0.234	12	0.089	0.081	0.085
4	0.212	0.204	0.208	13	0.080	0.072	0.076
5	0.190	0.182	0.186	14	0.068	0.064	0.066
6	0.170	0.162	0.166	15	0.061	0.057	0.059
7	0.152	0.144	0.148	16	0.055	0.051	0.053
8	0.137	0.129	0.133	17	0.049	0.045	0.047
9	0.122	0.114	0.118	18	0.044	0.040	0.042

NOTE 2.—"Standard Gage Rods" are usually considered to be steel rods of any convenient length which have been machined with fair accuracy to the proper gage diameter. Such steel rods are satisfactory for measuring the "dimensions" but are not recommended for use in testing "dielectric strength." When used for dielectric strength, the arc which forms when the tubing punctures will invariably raise a pimple of melted metal on the surface of the rod spoiling it for future use as a standard.

5. Specimens of any convenient length shall be cut from the samples as obtained in Section 2. **Specimens.**

6. The largest size gage rod that will fit the tubing without stretching it shall be inserted into the tubing. The inside diameter of the tubing shall be taken as the diameter of the gage rod. While the tubing is on the rod, outside diameter measurements shall be taken at distances 2 in. apart until five readings are obtained. The outside diameter of the tubing shall be the average of these five readings. **Procedure.**

NOTE.—In making measurements, care shall be taken to ascertain that all readings are taken on the first "click" of the micrometer ratchet.

7. The report shall include the inside diameter and the average, maximum, and minimum outside diameters in millimeters or inches. **Report.**

DIELECTRIC STRENGTH

8. The dielectric strength of the tubing shall be determined in accordance with the short-time dielectric strength procedure as described in Sections 2 to 12 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials.[1] **Test Procedure.**

9. (*a*) A convenient specimen length of the tubing shall be placed on the largest copper wire of standard B. & S. gage size that will fit without stretching it, and strips of metal foil 2.54 cm. (1 in.) in **Specimens and Electrodes.**

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[1] See p. 811.

width shall be tightly wrapped on the outside at a distance of not less than 7.62 cm. (3 in.) apart and at least 7.62 cm. (3 in.) from the ends of the specimen.

(*b*) The metal foil shall have a thickness not to exceed 0.0005 in. and the first turn of the foil applied to the tubing shall be wiped snugly against the tubing. Two more turns of the foil shall then be wound over this first turn, leaving a free end of ½ in. to which the electrical connection shall be made during the test. (See Note 2 under Section 4.)

Test Conditions. 10. (*a*) The test voltage shall be applied between the metal rod and each metal foil strip in turn.

(*b*) The tests shall be made in air with the specimen at room temperature.

(*c*) The dielectric strength shall be the average of ten puncturing voltages.

Report. 11. The report shall include the following:

(*a*) Total volts at each puncture.

(*b*) The average, maximum, and minimum puncturing voltages.

(*c*) The room temperature.

(*d*) The relative humidity, in per cent.

HEAT ENDURANCE

Specimens. 12. Not less than ten pieces, each 15.24 cm. (6 in.) in length shall be cut from the specimens.

NOTE.—If the heat endurance is in excess of 120 hours, additional specimens will have to be cut.

Procedure. 13. The pieces shall be placed in a uniformly heated electric oven of the analytical type in which the temperature is maintained between the limits of 105 and 110° C. (221 and 230° F.). Two pieces shall be removed at the end of 24 hours and every 24 hours thereafter until failure occurs. After cooling to room temperature of approximately 20° C. (68° F.), they shall be tested as follows:

Report. Each piece shall be bent through 180 deg. over a rod 0.32 cm. (⅛ in.) in diameter. The number of hours of baking at which first cracking across the specimen occurs shall be noted and reported.

IGNITION AND RATE OF BURNING

(*In the case of non-flammable or flame-resistant tubing*)

Apparatus. 14. The apparatus required for this test shall be a standard 1-in. Meker burner and a stop watch.

Specimens. 15. Specimens 9.16 cm. (4 in.) in length shall be cut from the samples as obtained in Section 2.

Procedure.

16. The flame of the Meker burner shall be turned to full height (blue flame) and the specimen shall be mechanically supported in a horizontal position in the flame at 5.08 cm. (2 in.) above the top of the burner.

NOTE.—The exposed edge of the tubing should extend about 1.27 cm. (½ in.) beyond the edge of the flame, in order to prevent the ignition of the cotton before the varnish film.

Ignition Time and Rate of Burning.

17. The time in seconds required for the specimen to ignite shall be noted, and after ignition the specimen shall be withdrawn and held in a horizontal position. If it continues to burn, the time in seconds required for it to burn along 2.54 cm. (1 in.) of length shall be noted.

Report.

18. (*a*) The ignition time shall be reported as the time in seconds required for ignition of the specimen.

(*b*) The rate of burning shall be reported as the number of seconds required for the specimen to burn along 2.54 cm. (1 in.) of length after ignition has taken place.

TENTATIVE METHODS OF TEST
FOR
GRADING NATURAL MICA ACCORDING TO SIZE, COMMERCIAL QUALITY, AND THICKNESS[1]

A.S.T.M. Designation: D 351 - 32 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These methods of grading cover all natural block mica and mica splittings for general use.

GRADING ACCORDING TO SIZE

Grade. 2. Natural mica shall be graded according to the area of the usable rectangle which can be cut from the specimen and the minimum dimension of one side. The mica in the usable rectangle shall meet the quality requirements specified by the purchaser.

A.S.T.M. Chart. 3. The tentative standard A.S.T.M. chart shown in Fig. 1 (Plate I) shall be used for grading natural block mica and mica splittings according to size.

Method of Grading for Size. 4. The specimen to be graded shall be laid upon the chart so that it covers point *O* and has its maximum and minimum dimensions extending along and covering the lines *OA* and *OB*, respectively. The specimen should be shifted until its usable area completely covers the largest rectangle determined by a diagonal extending from point *O* to or beyond a point on any of the curves, Nos. 6, 5½, 5, 4, 3, 2, 1, or A-1. The number of the curve at greatest distance from *O* cut by the diagonal of the rectangle designates the grade of the specimen.

NOTE.—The A.S.T.M. chart complies closely with the following so-called India grading scale, in general use for many years:

Grade	Area of Rectangle, sq. in.	Minimum Dimension of One Side
Extra Special	60 to 79⅞	....
Special	48 to 59⅞	....
A-1	36 to 47⅞	4 in.
1	24 to 35⅞	3 in.
2	15 to 23⅞	2 in.
3	10 to 14⅞	2 in.
4	6 to 9⅞	1½ in.
5	3 to 5⅞	1 in.
5½	2½ to 2⅞	1 in.
6	1 to 2⅜	¾ in.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N.Y.

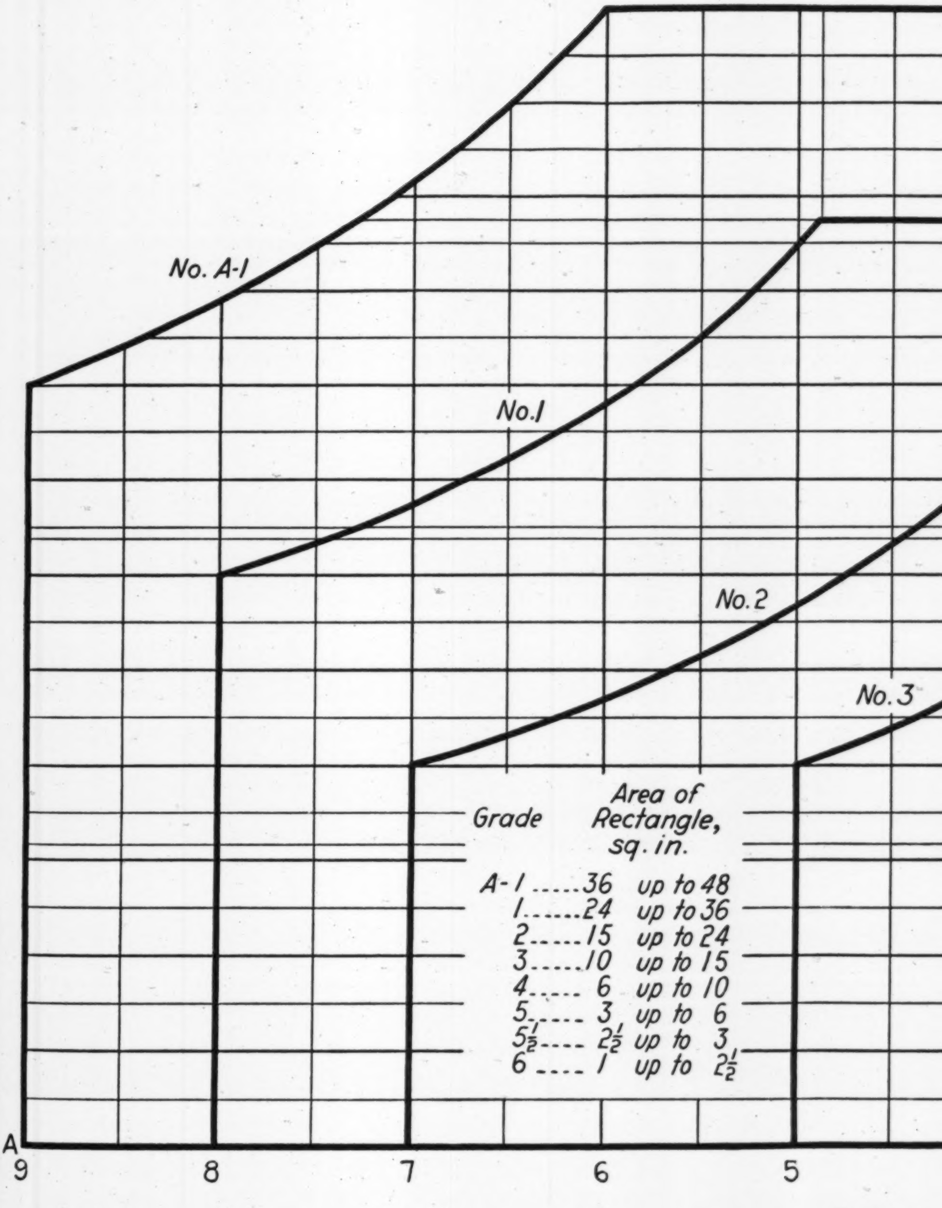

FIG. 1.—A.S T.M. Chart for Grading Natural Block

PLATE III.
PROCEEDINGS, AM. SOC. TESTING MATS.
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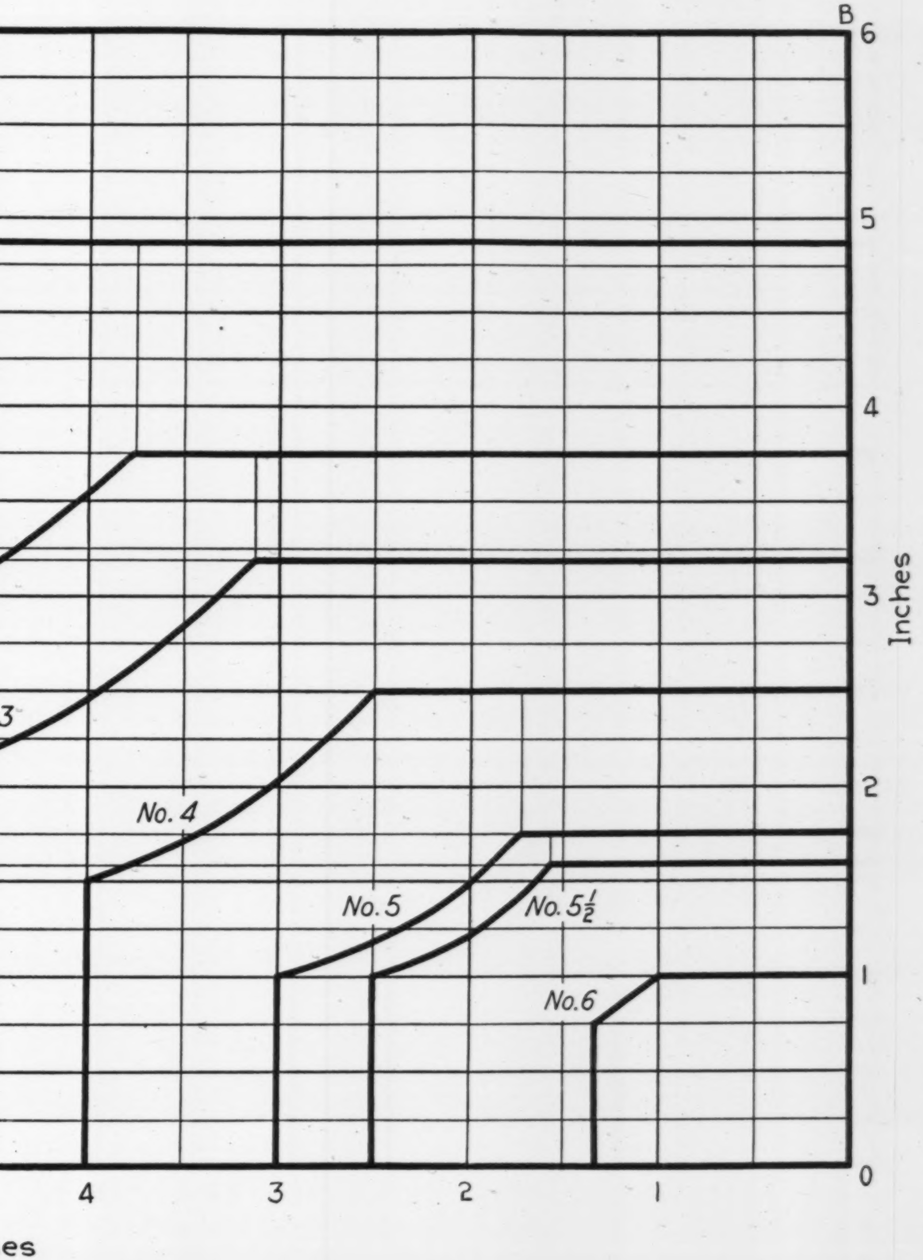
GRADING NATURAL MICA



ock Mica and Mica Splittings According to Size.

DETERMINATION OF COMMERCIAL QUALITY

Commercial Quality.

5. The commercial quality of mica shall be judged in terms of the following scale:

QUALITY	DESCRIPTION
Clear............	Free of all mineral and vegetable inclusions, stains, air inclusions, waves or buckles. Hard transparent sheets.
Clear and Slightly Stained	Free of all mineral and vegetable inclusions, cracks, waves, and buckles but may contain slight stains and air inclusions.
Fair Stained.....	Free of mineral and vegetable inclusions and cracks. Hard. Contains slight air inclusions and is slightly wavy.
Good Stained....	Free of mineral inclusions and cracks but contains air inclusions. some vegetable inclusions and may be somewhat wavy.
Stained..........	Free of mineral inclusions and cracks but may contain considerable clay and vegetable stains and may be more wavy and softer than the better qualities.
Black Stained or Spotted.....	Same as Stained but contains mineral inclusions.

NOTE.—It is proposed to prepare a set of master standards complying with the above descriptions, from which sets of photographic prints or transparent autochrome plates can be furnished.

THICKNESS[1]

Thickness.

6. Thickness measurements of mica shall be determined with a machinist's micrometer. In determining thickness of mica which must be held to close tolerances, or where two or more specimens are to be measured at once, *Method A* shall be used. Where the maximum accuracy is not required, *Method B* may be used.

Apparatus.

7. (*a*) The instrument used for determining thickness by *Method A* shall be a 1-in. machinist's type micrometer constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet mechanism having a coil spring, pin-type pawl, and having anvil and spindle surfaces $\frac{1}{4}$ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, wear of micrometer screw, micrometer screw error tolerances and ratchet pressure specified in Section 8 (*d*), (*e*), (*f*), (*g*), (*h*) and (*i*). Because of the abrasive nature of mica, the micrometer shall be tested and calibrated frequently for conformity to these requirements.

(*b*) The instrument used for determining the thickness by *Method B* shall be a 1-in. machinist's type micrometer equipped with vernier but without a ratchet device and shall have anvil and spindle surfaces ¼ in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, and micrometer screw error tolerances specified in Section 8 (*d*), (*e*), (*f*) and (*h*). Because of the abrasive nature of mica, the micrometer shall be tested and calibrated frequently for conformity to these requirements.

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[1] This thickness apparatus and procedure is the same as that used for the testing of insulating paper described in Sections 8 to 13 of the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M. Designation: D 202 – 32 T), see p. 839.

Cleaning Micrometer Surfaces.

8. (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of bond paper and moving the paper between the surfaces. The anvil and spindle surfaces of the micrometer shall be cleaned as frequently as necessary to prevent the accumulation of mica dust and to preserve the accuracy of measurements.

Procedure in Calibrating Method A Instruments.

(*b*) The manipulative procedure for calibrating controlled pressure instruments used in *Method A* shall be in accordance with the following:

The micrometer shall be closed on the gage or calibrating device and then opened 4 or 5 mils (0.004 or 0.005 in.). Using the ratchet, the micrometer shall be again closed so slowly on the calibrating device that the mil scale divisions may be easily counted as they move past the reference mark, or at the rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, when the reading shall be taken.

Procedure in Calibrating Method B Instruments.

(*c*) The manipulative procedure for calibrating instruments used in *Method B* shall be in accordance with the following:

The micrometer shall be slowly closed on the gage or calibrating device until contact of the surfaces and gage is made. The criterion of contact is the initial development of frictional resistance to movement of the gage device between the micrometer surfaces.

Flatness of Micrometer Surfaces.

(*d*) The anvil and spindle surfaces of the micrometer shall be flat to within 0.00005 in. The flatness may be determined by use of an optical flat, as follows:

After cleaning the surfaces of the flat and the micrometer (Paragraph (*a*)) the latter shall be closed on the flat as described in Paragraph (*b*) or (*c*). When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The location, shape and number of these bands indicates the deviation from flatness in increments of half the average of the wave lengths of white light, which is taken as 0.00001 in.

A *flat surface* forms straight, parallel and equidistant fringes.

A *grooved surface* forms straight parallel fringes at unequal intervals. The estimated maximum displacement of any line from its normal position, where all lines would be equidistant, is a measure of deviation from flatness.

A *symmetrical concave or convex surface* forms concentric circular fringes, and their number is a measure of deviation from flatness.

An *unsymmetrical concave or convex surface* forms series of curved fringes, cutting the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the termini of any fringe is a measure of the deviation from flatness.

Parallelism of Micrometer Surfaces.

(*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to within 0.0001 in. when tested with a pair of screw-thread-pitch wires whose diameters, accurate to 0.00002 in., differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils in the 1-in. micrometer). The micrometer shall be closed on the wire according to the procedure described in Paragraph (*b*) or (*c*). Observations, made with either wire placed at any location between the surfaces shall show differences of less than 0.0001 in.

Zero Reading.

(*f*) The position of the anvil shall be such that a zero reading is obtained when the micrometer is closed on the anvil as described in Paragraph (*b*) or (*c*). Ten trials shall give ten readings of zero.

Wear of Micrometer Screw.

(*g*) The device for compensating for wear of the micrometer screw shall be adjusted so that the spindle has no perceptible lateral or longitudinal looseness and yet may be rotated with a torque load of not more than $\frac{1}{4}$ in.-oz.

Micrometer Screw Error.

(*h*) The micrometer screw error, after zero adjustment is made, shall be checked at 2, 5 and 10 mils and at intervals of 100 mils over the remaining graduated scale. For checks up to and including a thickness of 10 mils selected gage blades the thicknesses of which are known to ±0.00002 in. shall be used. Checks at values greater than 10 mils shall be made with standard gage blocks. Three times the standard deviation for ten readings at each setting shall not exceed 0.1 mil (0.0001 in.). Manipulation of the instrument in these checks shall be in accordance with Paragraph (*b*) or (*c*).

Ratchet Pressure.

(*i*) The ratchet shall be so adjusted that a pressure of not more than 27 nor less than 23 lb. per sq. in. is developed when the spindle surface is contacted with a polished steel surface as described in Paragraph (*b*).

Method A:

Method A. 9. Method A is suitable for determining the thickness of mica which must be held to very close tolerances. The instrument used shall conform to the requirements specified in Section 7 (*a*).

Before starting measurements of thickness, the micrometer shall be closed on the specimen at a location outside the area to be measured. The micrometer shall then be opened not more than 4 or 5 mils (0.004 or 0.005 in.) and then moved into the area selected for measurement. Using the ratchet, the micrometer surfaces shall be closed so slowly on the specimen that the mil scale divisions may be easily counted as they move past the reference mark, or at a rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, and then the thickness shall be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

NOTE.—Care must be exercised in moving the micrometer from one measurement location to another, to maintain the surfaces of the anvil and spindle parallel to the surfaces of the specimen at all times so as to avoid scratching the mica and accumulating mica dust under the micrometer surfaces which will cause false readings.

Method B:

Method B. 10. Thickness measurements on mica, the acceptable tolerances of which may be wider than those requiring the use of Method A, shall be made according to Method B as follows:

In the determination of thickness, the micrometer specified in Section 7 (*b*) shall be slowly closed on the specimen until contact is made, without appreciable distortion of the specimen. The criterion of contact is the initial development of frictional resistance to movement of the specimen between the micrometer surfaces. The thickness shall then be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

NOTE.—Care must be exercised in moving the micrometer from one measurement location to another, to maintain the surfaces of the anvil and spindle parallel to the surfaces of the specimen at all times so as to avoid scratching the mica and accumulating mica dust under the micrometer surfaces which will cause false readings.

Report. 11. The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

TENTATIVE METHODS OF TESTING PASTED MICA USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 352 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

Scope. 1. These methods are intended to apply to the testing of mica sheets built up from mica splittings, bonded with an organic binder, to be used for hot molding, commutator insulation, heating plates and other similar insulating purposes.

DECREASE IN THICKNESS UNDER PRESSURE

Apparatus. 2. The apparatus shall consist of the following:

(*a*) A clamp for holding the test specimen of mica as illustrated in Fig. 1.

(*b*) An oven to obtain a temperature of 160° C. ± 5° C. (320° F. ± 9° F.).

(*c*) A hydraulic press to obtain a pressure of 2000 lb. per sq. in. on the mica.

(*d*) A micrometer gage to measure the thickness of the specimen to the nearest 0.001 in.

(*e*) A thermocouple or other temperature measuring device.

Specimen. 3. The test specimen shall consist of sufficient pieces, 3 by 2 in. in size, to form a stack approximately 1 in. in thickness.

Procedure. 4. (*a*) The specimen shall be placed in the clamp, Fig. 1, which is held together by means of bolts through the end holes. The clamp with specimen while cold shall be placed in the hydraulic press and a pressure of 100 lb. per sq. in. applied to the surface of the specimen.

(*b*) The thickness of the stack at the four corners shall be carefully determined by means of a micrometer gage, the average of these readings being taken as representing the thickness of the stack.

(*c*) The bolts of the clamp shall be tightened while the stack is under pressure so as to maintain the approximate pressure applied by the hydraulic press as described in Paragraph (*a*).

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 11, 1932.

(*d*) The specimen with clamp attached shall be placed in the oven at a temperature of 160° C. ± 5° C. (320° F. ± 9° F.) and allowed to remain for five minutes after reaching the oven temperature. A thermocouple placed in the specimen is suggested for accurately measuring the temperature.

(*e*) The specimen with clamp attached shall then be transferred as quickly as possible to the hydraulic press and a pressure of 2000 lb. per sq. in. on the surface of the specimen shall be applied immediately and maintained until the temperature of the specimen reaches the temperature at which the original thickness was determined. The thickness of the stack shall then be determined as described in Paragraph (*b*).

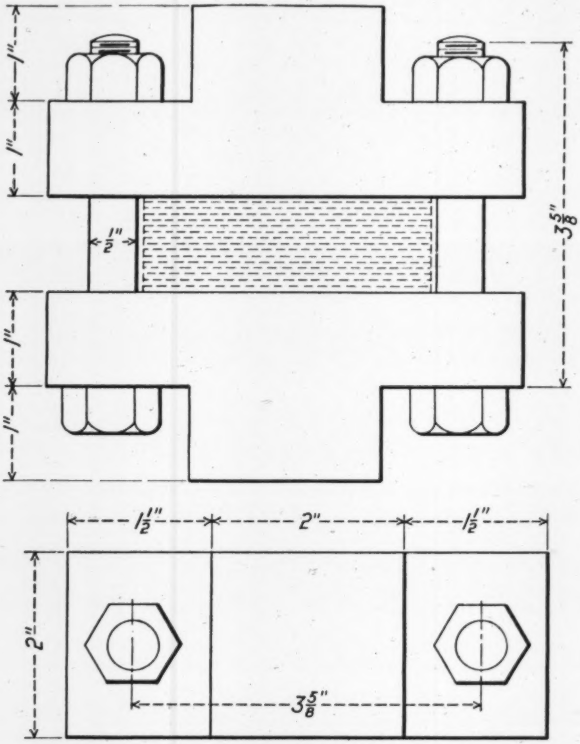

FIG. 1.—Clamp for Holding Test Specimen.

Report. 5. The report shall include the following:

(*a*) The thickness of the specimen before and after applying pressure.

(*b*) The percentage reduction in thickness, based on the original thickness.

STABILITY UNDER HEAT AND PRESSURE

Purpose. 6. The purpose of this test is to determine any tendency which the layers of mica may have to slip on each other, and whether the binder will be squeezed out when the sheet is subject to heat and pressure.

Apparatus. 7. The apparatus shall consist of the following:

(*a*) Eleven pieces of smooth sheet steel, 3 by 2 by $\frac{1}{32}$ in.

(*b*) A clamp for holding the mica as illustrated in Fig. 1.

(*c*) An oven to obtain a temperature of 230° C. ± 5° C. (446° F. ± 9° F.).

(*d*) A hydraulic press to obtain a pressure of 4400 lb. per sq. in. on the mica.

(*e*) A thermocouple or other temperature measuring device.

Specimen. 8. The test specimen shall consist of 10 pieces of mica, 3 by 2 in. by the thickness of mica.

Procedure. 9. (*a*) Alternate layers of mica and pieces of sheet steel shall be stacked, and each stack shall have a steel sheet on the top and bottom.

(*b*) The specimen shall be placed in the clamp, Fig. 1, which is held together by means of bolts through the end holes. The clamp with specimen while cold shall be placed in the hydraulic press and a pressure of 100 lb. per sq. in. applied to the surface of the specimen. The bolts of the clamp shall then be tightened while the stack is under pressure.

(*c*) The specimen, attached with clamp, shall then be placed in the oven at a temperature of 230° C. ± 5° C. (446° F. ± 9° F.) and allowed to remain five minutes after reaching the oven temperature. A thermocouple is suggested for accurately measuring the temperature of the specimen.

(*d*) The specimen with clamp shall then be transferred as quickly as possible to the hydraulic press and a pressure of 4400 lb. per sq. in. on the surface of the specimen applied immediately and maintained for 30 minutes.

(*e*) The mica in the stack shall be observed when the specimen is taken from the oven, when the hydraulic pressure is first applied, and during the period in the hydraulic press, especially during the first 5- or 10-minute period.

Report. 10. The report shall include the following:

(*a*) Whether the mica laminations slip or become displaced.

(*b*) Whether any binder exudes.

Mica or Binder Content

Purpose. 11. The purpose of this test is to ascertain the relative percentages of mica and bonding materials.

Apparatus. 12. The apparatus shall consist of the following·

(*a*) Bunsen burner.

(*b*) Platinum or porcelain dishes.

Specimen. 13. The specimen shall be $\frac{1}{2}$ by $\frac{1}{2}$ in. by the thickness of mica. Five specimens shall be tested.

Procedure. 14. (*a*) Each specimen shall be weighed to the nearest 0.0001 g. in a tared dish.

(*b*) The dish with the specimen shall be placed over a bunsen burner and heated at a low red heat (to avoid the dehydration of mica) until all the organic material and carbon are burned off. The contents shall then be carefully agitated by moving the dish to obtain complete combustion. After cooling in a desiccator, the weight of the residue shall be determined.

Report. 15. The report shall include the percentage loss in weight of the specimen indicated as binder and the percentage of residue in the crucible indicated as mica.

Molding Test

Purpose. 16. The purpose of the molding test is to measure the ability of the sheet to hold its shape when molded.

Apparatus. 17. (*a*) For specimens having a thickness of $\frac{1}{16}$ in. and less, a mandrel having a diameter of $1\frac{1}{2}$ in. shall be used.

(*b*) For specimens over $\frac{1}{16}$ in. up to and including $\frac{3}{32}$ in. in thickness a mandrel having a diameter of 2 in. shall be used.

Specimen. 18. The test specimen shall be 2 in. in width and of sufficient length to form a butt joint on the mandrel specified in Section 17 (*a*) or (*b*).

Procedure. 19. (*a*) The specimen shall be heated on a hot plate or a steam table at a specified temperature between the range of 90 and 125° C. (194 and 257° F.) and then formed around a mandrel as specified in Section 17 (*a*) or (*b*). The specimen shall then be rolled on a cold surface plate until it is cooled and the mandrel then removed.

Report. 20. The report shall include the following:

(*a*) The original thickness of the specimen in thousandths of an inch.

(*b*) Whether the mica sheet flakes and buckles.

(*c*) Whether the specimen retains its molded form.

DIELECTRIC STRENGTH

21. The dielectric strength values of the mica sheet material shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 32 T) of the American Society for Testing Materials,[1] either the A. Short-Time Dielectric Strength Test or the B. One-Minute Step-by-Step Dielectric Strength Test may be used as desired. **Dielectric Strength.**

RESISTIVITY

22. The resistivity shall be determined in accordance with the Tentative Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257 – 32 T) of the American Society for Testing Materials.[2] **Resistivity.**

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[1] See p. 810.

[2] See p. 873.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: PERFORMANCE RUBBER COMPOUND[1]

A.S.T.M. Designation: D 353 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. (*a*) These specifications cover wire and cable insulated with a vulcanized rubber compound. The suitability of the compound as insulation shall be determined solely by physical and electrical tests. The compound shall be called performance rubber compound.

(*b*) Except for the rubber insulation and cable tape, wire and cable supplied under these specifications shall conform to the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (A.S.T.M. Designation: D 27 - 31 T) of the American Society for Testing Materials.[2]

INSULATION

Workmanship. 2. (*a*) The insulation shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer adjacent layers shall be vulcanized into a homogeneous mass.

(*b*) Where tape under braid is specified, it shall conform to Sections 34 to 37, inclusive.

Tape used over insulation during vulcanization will be accepted where tape under braid is specified provided it conforms to the requirements of Sections 34 to 37, inclusive.

(*c*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 5.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 926 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 960.

MANUFACTURE

Composition.

3. The insulation shall consist of a properly vulcanized rubber compound that will meet the tests hereinafter specified.

PHYSICAL PROPERTIES

Physical Properties.

4. The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Ultimate tensile strength, lb. per sq. in.	..	1200
Tensile stress at 200 per cent elongation, lb. per sq. in.	..	300
Elongation at rupture, per cent	..	400
Set in 2-in. gage length, in.	$\frac{3}{8}$	....
Depreciation in tensile strength and elongation after oxygen bomb test, per cent	25	....
Depreciation in tensile strength and elongation after Geer oven test, per cent	15	....

THICKNESS

Thickness.

5. The average thickness of the insulation shall be not less than that given in Table I. The thickness of the insulation at the thinnest part shall be not more than 10 per cent less than the specified thickness, but in no case shall such 10 per cent allowance exceed 0.031 in.

TABLE I.—THICKNESS OF INSULATION.

Thickness in sixty-fourths of an inch

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	12	14	16	18	20	22	24
No. 8 to No. 2	8.37 to 33.6	4	5	7	9	10	12	14	16	18	20	22	24
No. 1 to No. 0000	42.4 to 107	5	6	8	10	10	12	14	16	18	20	22	24
250 000 to 500 000 cir. mils	127 to 253	6	8	9	10	11	12	14	16	18	20	22	24
550 000 to 1 000 000 cir. mils	279 to 507	7	9	10	10	12	12	14	16	18	20	22	24
1 250 000 to 2 000 000 cir. mils	633 to 1013	8	10	10	10	12	14	16	18	18	20	22	24

NOTE.—The thickness of insulation (on each conductor in the case of multiple conductor cables) shall be based on the highest r. m. s. voltage between the conductor and the outside of its insulation.

For an intermediate size, the thickness shall be that of the next larger size.

ELECTRICAL PROPERTIES

High Voltage Test.

6. Each coil, reel, or length of wire or cable after vulcanization and before the application of any covering other than tape or braid used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table II for a period of 5 minutes.

Insulation Resistance.

7. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 6 shall have an insulation resistance not less than that given in Table III.

Moisture Absorption.

8. The increase in the specific inductive capacity of the insulation shall be used as an indication of the amount of moisture absorbed.

The initial specific inductive capacity shall not exceed six; the increase between the first and the fourteenth day shall not exceed 20 per cent, and that between the seventh and the fourteenth day 5 per cent.

The measurements shall be made as described in Section 32.

TABLE II.—ALTERNATING TEST VOLTAGE IN KILOVOLTS.

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	13	16	17	18	20	22	24
No. 8 to No. 6	8.37 to 13.3	3.5	5	7	9	10	13	16	17	18	20	22	24
No. 5 to No. 2	16.8 to 33.6	3.5	5	7	9	10	13	16	19	22	25	28	31
No. 1 to No. 0000	42.4 to 107	3.5	6	8	10	10	13	16	19	22	25	28	31
250 000 to 500 000 cir. mils	127 to 253	4	8	9	10	11.5	13	16	19	22	25	28	31
550 000 to 1 000 000 cir. mils	279 to 507	4	9	10	10	13	13	16	19	22	25	28	31
1 250 000 to 2 000 000 cir. mils	633 to 1013	4	10	10	10	13	16	19	22	22	25	28	31

NOTE.—For an intermediate size or an intermediate working voltage, the test voltage shall be that of the next larger size, or working voltage listed.

METHODS OF TESTING

PHYSICAL AND ACCELERATED AGING TESTS ON INSULATION

Sampling.

9. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft.	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft.	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft.	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimen.

10. (*a*) *Size.*—For the physical tests, the test specimen may be the entire cross-section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment or sector cut with a sharp knife held tangentially to the conductor or a shaped

specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

TABLE III.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).[a]

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	12 900	14 800	15 800	16 900	18 000	19 800
No. 16	7400	9 500	11 400	12 700	14 000	15 000	16 100	18 000
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	5 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No. 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch						
	12	14	16	18	20	22	24
No. 18	21 400	22 700	23 800	24 800	25 900	26 400	27 200
No. 16	19 300	20 900	21 900	23 000	23 800	24 600	25 300
No. 14	17 700	18 700	20 100	20 900	21 600	22 700	23 200
No. 12	15 800	17 200	18 000	19 000	19 800	20 600	21 400
No. 10	14 000	15 300	16 400	17 200	18 000	18 700	19 500
No. 8	11 600	12 700	13 700	14 500	15 300	16 100	16 600
No. 6	10 300	11 100	12 100	12 900	13 500	14 300	14 800
No. 4	8 700	9 800	10 600	11 400	11 900	12 700	13 200
No. 2	7 650	8 400	9 000	9 800	10 300	11 100	11 600
No. 1	7 150	7 650	8 400	9 200	9 800	10 300	10 800
No. 0	6 350	7 150	7 900	8 400	9 000	9 500	10 000
No. 00	5 550	6 600	7 150	7 900	8 400	9 000	9 500
No. 000	5 300	6 050	6 600	7 150	7 650	8 200	....
No. 0000	5 000	5 550	6 050	6 600	7 150	7 650	....
250 000 cir. mils	4 600	5 300	5 800	6 350	6 750	....	....
350 000 cir. mils	4 100	4 500	5 000	5 550	5 950	....	....
500 000 cir. mils	3 550	3 950	4 500	4 750	....	....	....
750 000 cir. mils	2 750	3 300	3 700	4 100	....	....	....
1 000 000 cir. mils	2 500	2 900	3 300	....	....	....	....
1 250 000 cir. mils	2 250	2 650	3 050	....	....	....	....
1 500 000 cir. mils	2 100	2 500	....	....	....	....	....
1 750 000 cir. mils	2 000	2 400	....	....	....	....	....
2 000 000 cir. mils	1 700	2 250	....	....	....	....	....

[a] This table is based on a constant, $K = 21\,120$ in the following formula:

$$R = K \log_{10}\frac{D}{d};$$ where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE.—For an intermediate size, the insulation resistance shall be that of the next larger size.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire cross-section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications.

Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed.

No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area.

11. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the average outside diameter of the insulation and the area of the conductor. The area of the stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a segment or sector of the insulation has to be taken in the case of a large wire or cable or where the insulation is thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test specimen or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

Temperature at Test.

12. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Testing Machine.

13. The testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Tests.

14. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length

of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test.

15. The tensile stress test shall be made in conjunction with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the area of the original specimen.

Elongation at Rupture.

16. Elongation at rupture shall be determined in conjunction with the tensile strength test by reading the distance in inches between gage marks at the breaking point. The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test.

17. The set test shall be made on a second test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

Aging Test Conditions.

18. (*a*) For the aging tests, nine test specimens sampled in accordance with Section 9 taken from the same length of insulation shall be used; three for the determination of unaged properties, three for the oxygen bomb test and three for the Geer oven test.

(*b*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*c*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*d*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*e*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*f*) Physical tests on both the aged and unaged samples shall be made at the same time. The aged samples shall have a rest period of not less than 16 hours nor more than 48 hours between the completion of the aging test and determination of physical properties.

(*g*) Should the first set of specimens selected under Paragraph (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Oxygen Bomb Test. 19. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test. 20. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Rejection. 21. Where ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests.

THICKNESS MEASUREMENTS

Apparatus. 22. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements. 23. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure. 24. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any point and the average diameter of the conductor measured at the same point. The minimum thickness shall be as taken the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection. 25. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place. 26. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test. 27. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve

Rate of Application. 28. The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Grounding. 29. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

(*b*) In the case of multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage. 30. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

TABLE IV.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

Insulation Resistance.

31. (*a*) The insulation resistance shall be measured after the high voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table IV.

Temperature Coefficient.

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.6° C.), the resistance shall be reduced to that at 60° F. (15.6° C.) by multiplying the measured value by the coefficient in Table IV corresponding to the temperature at which the measurement was made.

Moisture Absorption Test.

32. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the 2½-ft. portion at each end kept above the water as

leakage insulation. The three measurements specified in Section 8 shall be taken with the water at the same temperature. The water shall be maintained at room temperature but not less than 70° F. (21° C.).

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13\,600\ C \log_{10} \frac{D}{d}$$

where C = the capacity in micro-farads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

Rejection. 33. Each coil, reel or length which fails to comply with the electrical requirements of these specifications shall be rejected.

CABLE TAPE

Material. 34. The tape shall be made from cotton cloth having a weight of not less than 1 lb. per 4 yd. with a width of 36 in. and not less than 56 by 60 picks per inch, and shall be frictioned on both sides and thoroughly filled with a rubber compound.

TABLE V.—WIDTH AND OVERLAP FOR RUBBER-FILLED CLOTH TAPE.

DIAMETER OVER INSULATION, IN.	WIDTH, MAXIMUM, IN.	OVERLAP, MINIMUM, IN.
2.00	5	$\frac{1}{2}$
1.75	$4\frac{1}{2}$	$\frac{1}{2}$
1.50	4	$\frac{1}{2}$
1.25	$3\frac{1}{2}$	$\frac{1}{2}$
1.15	$3\frac{1}{4}$	$\frac{1}{2}$
1.00	3	$\frac{1}{2}$
0.88	$2\frac{3}{4}$	$\frac{3}{8}$
0.75	$2\frac{3}{8}$	$\frac{3}{8}$
0.62	2	$\frac{3}{8}$
0.50	$1\frac{3}{4}$	$\frac{3}{8}$
0.38	$1\frac{1}{2}$	$\frac{1}{4}$
0.31	$1\frac{1}{4}$	$\frac{1}{4}$
0.25	1	$\frac{1}{4}$
0.19	$\frac{7}{8}$	$\frac{1}{8}$
0.16	$\frac{3}{4}$	$\frac{1}{8}$

Application. 35. The tape shall be applied helically. The maximum width and minimum overlap shall conform to the values in Table V.

Intermediate Diameters. 36. For intermediate diameters the requirements shall be those of the next smaller diameter indicated in Table V.

Number of Tests. 37. Samples shall be taken at the option of the purchaser.

TENTATIVE SPECIFICATIONS
FOR
FRICTION TAPE FOR GENERAL USE FOR ELECTRICAL PURPOSES[1]

A.S.T.M. Designation: D 69 - 32 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued as Tentative, 1920; Adopted in Amended Form, 1924; Revised, 1928; Reissued as Tentative in Amended Form, 1932.

Scope. 1. These specifications cover commercial friction tape consisting of strips of cotton sheeting impregnated with an adhesive insulating compound. The tape is for use in binding and protecting insulation applied to joints of wires and cables, and for other electrical and mechanical purposes.

Manufacture

Cotton Sheeting. 2. The cotton sheeting shall be evenly and firmly woven from good cotton and as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. The threads shall run in as straight lines as possible, without waving, so as to reduce to a minimum the ravelling of the cloth when cut into tape.

Frictioning Compound. 3. The frictioning compound shall be an adhesive and insulating compound practically free from free sulfur and other substances which would have a deteriorating effect on copper or other metals, or on the fabric.

Impregnation of Fabric. 4. The fabric shall be thoroughly impregnated and evenly covered on both sides with the frictioning compound.

Adhesiveness of Compound. 5. The compound shall adhere firmly to the fabric, and shall not pull away from the fabric so as to leave bare spots when adjacent layers of tape are separated.

Chemical Properties

Discoloration of Copper. 6. Five superimposed layers of tape shall be wound on a clean, bright, smooth copper rod, approximately $\frac{1}{4}$ in. in diameter and 3 in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

These tentative specifications are in effect a revision of the former Standard Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 - 28), see 1930 Book of A.S.T.M. Standards, Part II, p. 1036, which were discontinued in 1932.

in length, and baked at 100° C. for 16 hours in a sealed test tube. At the conclusion of the test·the blue-black color, characteristic of copper sulfide, shall not appear on the rod at the edge of the tape. This test shall be made only when requested by the purchaser.

PHYSICAL PROPERTIES AND TESTS

Pinholes. 7. The number of pinholes in 3 yd. of tape shall not exceed six for $\frac{3}{4}$-in., eight for 1-in., twelve for $1\frac{1}{2}$-in., and sixteen for 2-in. tape. Ruptures of the insulating film at the extreme edges of the tape, due to the slight tearing action of the cutting knives, shall not be considered pinholes.

Determination of Pinholes. 8. The number of pinholes shall be determined while the tape is held over a slot in the top of an illuminated box. The box shall be 8 by 8 by 18 in., inside dimensions, and the slot shall be 2 in. in width by 12 in. in length. The box shall be painted white inside and illuminated by a 25-watt lamp. The slot shall be covered with clear glass set flush with the top of the box. Means shall be provided to limit the light to the width of the tape.

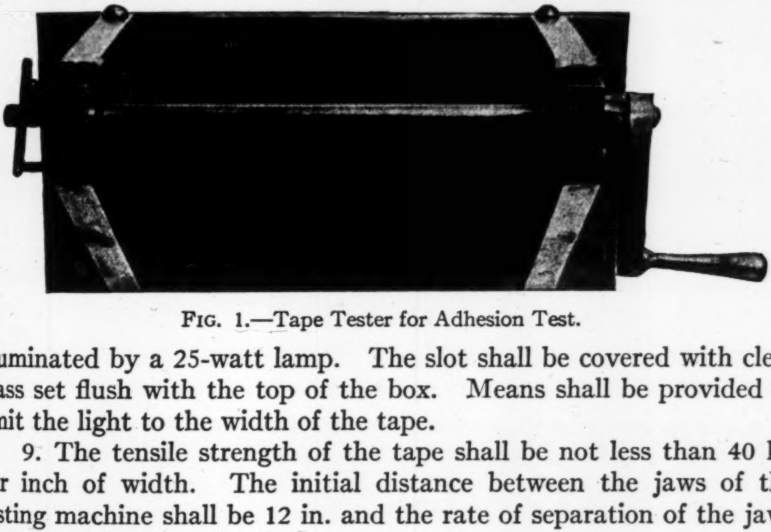

FIG. 1.—Tape Tester for Adhesion Test.

Tensile Strength. 9. The tensile strength of the tape shall be not less than 40 lb. per inch of width. The initial distance between the jaws of the testing machine shall be 12 in. and the rate of separation of the jaws shall be 20 in. per minute.

Friction. 10. (*a*) The adhesion between adjacent layers of tape shall be determined as follows: A sample 23 in. in length shall be removed from the roll, care being taken not to touch the surface to be tested with the hands or otherwise. Two inches of the sample shall be wound on the mandrel described below and a weight of 10 lb. per inch of width attached to the end of the sample; 19 in. of the sample shall then be wound onto the mandrel at a uniform rate of 12 in. per minute. The tape shall be allowed to stand 3 minutes with the weight attached, after which a weight of 4 lb. per inch of width of tape shall be substituted for the weight of 10 lb. per in. of width, and the tape allowed to unwind; after 2 in. have unwound, the rate of unwinding shall not be greater than 15 in. in 1 minute. The temperature of the room and the temperature of the tape shall be not less than 20° C. (68° F.) nor more than 22.2° C. (72° F.) The mandrel used shall be ¼ in. in diameter, and shall be mounted in a level position in ball bearings of the Fafnir Bearing Co., Catalog No. 0.096, or equivalent ball bearings. The mandrel shall turn freely under a weight of ¼ oz., suspended from a cotton thread wound in a single layer on the center of the mandrel. See Fig. 1, for a suggested form of tape tester.

(*b*) After a strip of tape has been exposed to dry air at a temperature of not less than 99° C. (210.2° F.) nor more than 101° C. (213.8° F.) for 16 hours, and then cooled to room temperatures, a test specimen shall withstand the test prescribed in Paragraph (*a*) except that the weight applied to unwind the tape shall be 3 lb. per inch of width in place of 4 lb.

Dielectric Strength. 11. Each roll selected for purpose of test shall be tested for dielectric strength. The breakdown voltage shall be not less than 1000 volts.

Dielectric Strength Test. 12. The dielectric strength shall be determined by placing a sample specimen between two flat electrodes, ¼ in. in width by 4 in. in length, having square edges and rounded ends. Under an electrode pressure of 1.1 lb. per sq. in., a 60-cycle alternating voltage of practically sine wave form, shall be applied at a value not exceeding 100 volts and raised at the rate of 100 volts per second until puncture occurs. In order to prevent flash over, increased width may be secured by attaching to each side of the test specimen an added piece of tape, making a ⅛-in. lap seam carefully rolled down.

Parallelism Test. 13. Each sample roll shall be tested for parallelism of the warp threads with the longitudinal axis as follows. A 16-in. piece shall be cut off from the length unwound and then torn lengthwise, assisting the tearing by first slitting one end for about ½ in. with a knife. A 2-in. length shall then be cut from each end of one of the torn halves and the ends of the remaining 12-in. length folded together and compared. The difference between the compared widths shall not exceed ⅛ in.

Sampling. 14. The number of rolls taken at random as representative samples for purpose of tests shall vary with the number of rolls ordered as follows:

	Number of Rolls Selected
Up to 250 rolls	1
251 to 1000 rolls	2
1001 to 2000 rolls	3
2001 to 4000 rolls	4
Over 4000 rolls	4 plus 1 roll for each additional 2000 rolls or fraction thereof

(*b*) At least, 2 ft. of the outer layers shall be removed and discarded before taking test specimens.

Dimensions and Permissible Variations

Dimensions. 15. (*a*) The tape shall have a nominal thickness of 0.015 in. and be made in the following widths: $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., and 2 in. Each roll shall contain at least $82\frac{1}{2}$ ft. of tape.

Permissible Variations. (*b*) The thickness shall not vary from that specified more than ±0.002 in. nor the width more than $\pm\frac{1}{32}$ in.

Measurement of Thickness. 16. The thickness shall be measured with a micrometer graduated to 0.001 in., having a circular foot 0.24 to 0.26 in. in diameter, and with a pressure on the specimen of not less than 5 oz. nor more than 10 oz. Five measurements shall be made at random in a length of not less than 3 ft.

Packing and Marking

Packing. 17. Each roll shall be wrapped in paraffined paper or metal foil. and enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking. 18. Each box shall be marked with the name of the manufacturer or trade mark, together with the nominal width and length of the tape.

Inspection and Rejection

Time of Inspection. 19. The tape shall be inspected and tested at the factory or within four weeks from the date of delivery.

Storage Guarantee. 20. The manufacturer shall guarantee to replace tape which at any time within 8 months after acceptance of the tape, if properly stored, will not meet the adhesion test specified in Section 10 (*a*) except that a weight of 3 lb. per inch shall be substituted for the 4 lb. per inch, during unwinding. The tape shall be stored in the original boxes and preferably in a cool, dark location. It shall not be stored in close proximity to steam pipes, radiators or other sources of heat.

Retests and Rejections. 21. If the tape fails in any one test of those prescribed in these specifications, two additional specimens shall be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape represented shall be rejected.

TENTATIVE SPECIFICATIONS

FOR

RUBBER INSULATING TAPE[1]

A.S.T.M. Designation: D 119 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1927, 1928, 1932.

Scope. 1. These specifications cover rubber insulating tape to be used for insulating joints in electric wires and cables, and for other insulating purposes.

MANUFACTURE

Compound. 2. The tape shall be made from an unvulcanized rubber compound which shall be well, evenly, and smoothly calendered, cut to uniform width and tightly wound in rolls with a glazed cloth, parchment paper or linen separator interposed between adjacent layers.

Separator. 3. The separator shall be attached to and cover the outer side of the tape; when unwound from the original roll, it shall show no undue tendency to stick to the rubber.

CHEMICAL PROPERTIES AND TESTS

Composition. 4. The tape shall consist of a rubber compound containing not more than 1 per cent of free sulfur.

Chemical Analysis. 5. If an analysis of the compound is made, the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials[2] shall be employed.

PHYSICAL PROPERTIES AND TESTS

Tensile Strength. 6. (*a*) The tensile strength of the tape shall be not less than 200 lb. per sq. in.

Elongation. (*b*) The elongation of a 2-in. gage length, determined when the tensile strength test is made, shall be not less than 300 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthu W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] 1932 Supplement to Book of A.S.T.M. Standards, p. 49.

Tensile Strength and Elongation Tests.

7. The tests for tensile strength and elongation shall be performed in accordance with the Standard Methods of Physical Testing of Rubber Products (A.S.T.M. Designation: D 15) of the American Society for Testing Materials,[1] with the following exceptions:

(*a*) Three specimens, free from visible defects, from each sample roll shall be tested; these specimens shall be taken after at least 2 ft. of the tape have been unwound and discarded. The average of the three tests per roll shall be reported.

(*b*) The test specimens shall be dumb-bell shape, die cut, ½ by 2-in. A.S.T.M. standard die; it is understood that in testing ¾-in. tape, the wide ends of the test piece will be only ¾ in. in width. The test specimens shall be cut from a laminated sample, 2 plies thick, carefully rolled together to avoid entrapped air; this will give a test specimen approximately 0.060 in. in thickness.

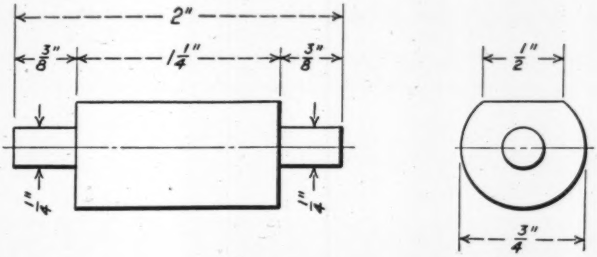

FIG. 1.—Mandrel for Fusion Test.

(*c*) In placing the parallel gage marks on the test specimen, care shall be exercised not to cut the stock.

(*d*) The tape shall have been maintained at the standard room temperature for at least 30 minutes previous to the time of testing.

8. The dielectric strength of the tape shall be not less than 350 volts per mil of thickness.

Dielectric Strength Test.

9. The dielectric strength shall be determined by placing a specimen between two flat electrodes ¼ in. in width by 4 in. in length having square edges and rounded ends. Under an electrode pressure of 3.3 lb. per sq. in. a 60-cycle alternating voltage of practically sine wave form shall be applied at a value less than 1000 volts and raised at the rate of 1000 volts per second until puncture occurs. In order to prevent flash over, increased width may be secured by attaching to each side of the test specimen an added piece of tape, making a ⅛-in. lap seam carefully rolled down.

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 73.

Fusion Test. 10. The tape shall be tested for fusion as follows:

(*a*) The temperature of the room in which the tests are being made shall be between 72 and 82° F. The samples shall be kept within these limits of temperature for a period of at least 30 minutes prior to the time of testing.

(*b*) Two 12-in. specimens ¾ in. in width shall be taken from each test roll after at least 2 ft. have been discarded; 10 in. of one specimen shall be wound on one mandrel, and the same length of the other specimen on another mandrel. The mandrels shall be of the design as shown in Fig. 1. The strips shall be wound up under a tension of 9 oz., and with opposite surfaces exposed. The test strips shall not be handled any more than is necessary to start winding them on the mandrels. Care shall be taken that the outer surface of the tape on the flat side of each mandrel does not come in contact with the fingers or other objects. The flat surfaces of the mandrels shall then be placed opposite to and parallel with each other and pressed together under a load of 7½ lb. for a period of 3 minutes. One mandrel shall then be suspended in a yoke and a dead wight of 7½ lb. applied to the other mandrel in such a way as to tend to separate the two tape surfaces in contact. After one minute's application of this dead weight pull, the two tape specimens shall not have completely separated at the contact plane.

Sampling. 11. (*a*) The number of rolls taken at random as representative samples for purpose of tests shall vary with the number of rolls ordered as follows:

	NUMBER OF ROLLS SELECTED
Up to 250 rolls	1
251 to 1000 rolls	2
1001 to 2000 rolls	3
2001 to 4000 rolls	4
Over 4000 rolls	4 plus 1 roll for each additional 2000 rolls or fraction thereof

(*b*) At least 2 ft. of the outer layer of each roll shall be removed and discarded before taking test specimens.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions. 12. (*a*) The tape shall be made 0.030 in. in thickness in the following widths and lengths:

¾-in. width	at least 30-ft. or at least 15-ft. length per roll
2-in. width	at least 15-ft. length per roll

Permissible Variations. (*b*) The thickness shall not vary from the specified value by more than ±0.003 in.; the width shall not vary from the specified value by more than $\pm\frac{1}{32}$ in.

13. Measurements of thickness shall be made in accordance with Section 7 (*d*) of the Standard Methods of Physical Testing of Rubber Products (A.S.T.M. Designation: D 15) of the American Society for Testing Materials.[1]

PACKING AND MARKING

Packing. 14. Each roll shall be wrapped in paraffined paper or metal foil, and enclosed in a suitable box; the wrapping shall be secureand shall thoroughly protect the contents.

Marking. 15. Each box shall be marked with the name of the manufacturer or trade mark and the nominal width and length of the tape.

INSPECTION AND REJECTION

Inspection. 16. The tape shall be tested and inspected at the factory or within four weeks from the date of delivery.

Retests and Rejection. 17. If the tape fails in any one test of those prescribed in these specifications, two additional specimens shall be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape shall be rejected.

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[1] 1932 Supplement to Book of A.S.T.M. Standards, p. 73.

TENTATIVE SPECIFICATIONS

FOR

TOLERANCES AND TEST METHODS FOR RAYON[1]

A.S.T.M. Designation: D 258 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927, 1931, 1932.

DEFINITIONS

Definitions.

1. (*a*) *Rayon* (formerly known as artificial silk).—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament, or filaments, by means of some precipitating medium.

(*b*) *Rayon Yarns.*—Yarn composed of more than one continuous rayon filament.

(*c*) *Spun Rayon.*—Yarn made from cut rayon filaments, the cut filaments being twisted and drawn out into a yarn by usual spinning processes.

Classification.

2. (*a*) *Nitro-Cellulose Rayon* (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

(*b*) *Viscose Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose xanthate.

(*c*) *Cuprammonium Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

(*d*) *Cellulose-Acetate Rayon.*—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

IDENTIFICATION

Identification Methods.

3. Any rayon tested by these methods shall be in the bleached or unbleached state and shall be free from oil or other foreign substances.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

A suggested procedure for removing the oil or other foreign substances is to rinse the rayon in (*a*) boiling water, (*b*) denatured alcohol, and (*c*) ethyl ether, then allow to dry at room temperature.

TO DISTINGUISH CELLULOSE-ACETATE FROM ALL OTHER RAYONS

4. Cellulose acetate rayon is distinguished from the regenerated cellulose rayons by its solubility in pure acetone or in glacial acetic acid, if acetone is not available. A small sample of cellulose acetate rayon will dissolve completely in a few minutes; the cellulose rayons are insoluble. The result of this test can be confirmed by twisting the fibers to a tight wad and cautiously applying the flame of a lighted match. Cellulose acetate rayon fuses and burns and hardens at once into a brittle substance, globular in appearance.

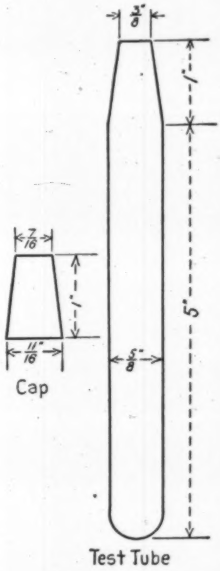

FIG. 1.—Special Test Tube With Cap.

TO DISTINGUISH NITRO-CELLULOSE RAYON FROM VISCOSE AND CUPRAMMONIUM RAYONS

5. If the rayon is not cellulose acetate, moisten it with a 1-percent solution of diphenylamine in a mixture of two parts of concentrated sulfuric acid and one part of glacial acetic acid. (This mixture of acids is recommended instead of sulfuric acid alone as it does not dissolve rayon so quickly and the color persists longer.) Nitrocellulose rayon assumes a deep blue color immediately and the fibers

dissolve rapidly to a blue solution. Viscose and cuprammonium rayons are not colored blue and dissolve more slowly.

TO DISTINGUISH VISCOSE RAYON FROM CUPRAMMONIUM RAYON

6. If the rayon is neither cellulose acetate nor nitro-cellulose rayon, test it for sulfide sulfur. A special test tube with cap of the construction shown in Fig. 1 is convenient for this test in order to protect the test paper from contamination by sulfide in the air.

Introduce 0.5 g. of the rayon into the test tube and add 10 ml. of a 3-per-cent sulfuric acid solution. Place a piece of filter paper, previously soaked in a 10-per-cent lead acetate solution, over the opening of the tube and hold it in position by means of the cap. Immerse the tube to a depth of about 4 in. in a steam bath and heat for 4 hours. If at the end of this period the exposed part of the lead acetate paper becomes stained with a brown or black color (indicating the presence of sulfide sulfur), the sample is viscose rayon. Cuprammonium rayon gives a negative test.

NOTE.—In the opinion of the committee, (1) none of the staining methods thus tar proposed can be invariably depended upon to distinguish between viscose and cuprammonium rayon, and (2) no thoroughly reliable method of identifying cuprammonium yarn has been discovered.

TOLERANCES

SIZE OR YARN NUMBER (DENIER)

Size of Rayon Yarn.

7. The denier of a yarn is the weight in grams of 9000 meters.

8. (*a*) The average size or denier of each skein, tube, spool, cop, pirn or cone of rayon as supplied by the seller either bleached or unbleached, as found by test, shall not vary above or below the specified size or denier more than:

10 per cent for sizes finer than 150 denier, and
8 per cent for 150 denier or coarser.

(*b*) The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of rayon yarn in the singles, either bleached or unbleached, as found by test shall not vary above or below the specified size more than:

5 per cent for sizes finer than 150 denier, and
4 per cent for 150 denier or coarser.

Size of Spun Rayon Yarn.

9. The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of spun rayon yarn in the singles, either bleached or unbleached, as found by test, shall not vary more than 5 per cent above or below the specified size.

TWIST

Definition.

10. *Direction of Twist.*—The direction of twist shall be as defined in the Standard Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123) of the American Society for Testing Materials, as follows:

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand or regular twist if when it is held vertically the spirals or twists are seen to incline upward in a right-hand direction and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

NOTE.—Attention is called to the fact that this definition of twist is opposite to that used in the silk trade.

Average Twist.

11. The average twist of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn shall not vary beyond the following specified limits:

TURNS PER INCH	ALLOWABLE VARIATIONS
Under 7½	±25 per cent
7½ to 10	±15 per cent
Over 10	± 5 per cent

STRENGTH

Tensile Strength.

12. (*a*) The average tensile strength of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn in the singles, or plied, either bleached or unbleached, as found by test, shall not be less than the specified strength.

(*b*) Ultimate strength, or strength at the highest yield point, may be specified.

METHODS OF TESTING

SIZE OR YARN NUMBER (DENIER)

(*A*) *Preferred Method*

Size, Preferred Method.

13. The number or denier shall be determined (except when the rayon is on beams) from skeins which have been prepared, reeled, and weighed under prevailing atmospheric conditions from the spools, cops, tubes, cones, skeins, or other packages.

Test Skein.

14. Any reel employing a straight wind traverse having a perimeter of 112.5 cm. may be used. (See Note.) For yarns in skein form, a speed of 100 to 150 r. p. m. shall be used. For yarns on spools, cops, tubes or cones, the yarn shall be drawn off over end and a speed of 200 to 300 r. p. m. of the reel shall be used. The tension on the yarn

shall not be heavier than is necessary to lay the yarn smoothly on the reel at the specified speed. The skeins shall be weighed separately on a balance which shall be accurate to 0.25 per cent of the average weight of one skein.

NOTE.—In a laboratory which is equipped for testing cotton yarns only, the skeins may be prepared on any reel having a perimeter of 1½ yd. Each skein must contain 200 ends as before.

If a skein of this length is used the yarn number or denier shall be calculated from the following formulas:

If the weighing is made in grams.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grams} \times 1.64}{0.05 \text{ gram (per denier)}}$$

If the skeins are weighed in grains.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grains} \times 1.64}{0.7716 \text{ grain (per denier)}}$$

Number of Tests.

15. Two skeins of 200 turns each from each of 10 spools, cops, tubes, cones or skein bundles, from one case out of every 10 cases shall be made, and the average of these 20 tests shall be the size or denier.

16. Rayon received on beams shall be tested as specified.

Weight Correction.

17. The weight of each skein shall be reduced to a common basis of standard moisture regain for the class of rayon under test by the following formulas:

(*a*) For nitro-cellulose, viscose and cuprammonium rayons:

$$\text{Weight, corrected to 11 per cent moisture regain} = \frac{\text{Actual skein weight} \times 111}{100 + \text{actual percentage of regain}}$$

(*b*) For cellulose acetate rayons:

$$\text{Weight, corrected to 6.5 per cent moisture regain} = \frac{\text{Actual skein weight} \times 106.5}{100 + \text{actual percentage of regain}}$$

Regain in Sizing Skeins.

18. To determine the actual percentage of moisture regain present in the sizing skeins, two groups of three skeins each shall be taken immediately after weighing and the weight of each group recorded. They shall then be placed in two separate baskets in a conditioning oven and dried to constant weight on a balance sensitive to 0.25 per cent of the average weight of one skein at 105 to 110° C. (221 to 230° F.). The moisture regain of each group shall then be computed as the percentage of the dry weight and the average of these two shall be the actual percentage of moisture regain in the sizing skeins.

Calculation.

19. The size or yarn number in denier is calculated as follows:

$$\text{Denier size or yarn number} = \text{Corrected weight of 225-meter skein in grams} \times 40$$

20. The yardage per pound of rayon of any given denier may be calculated by the following formula:

$$\text{Yards per pound of rayon} = \frac{4{,}464{,}528}{\text{Given denier}} \text{ (yards per pound of one denier yarn)}$$

(*B*) *Alternate Method*

Size, Alternate Method.

21. The winding of the skeins shall be done under prevailing atmospheric conditions following the procedure outlined in Sections 13 to 15 and these test skeins shall be conditioned for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity at 70° F. (21° C.) and then weighed in this atmosphere.

22. The size or yarn number in denier shall be calculated from the following formula:

$$\text{Size or yarn number} = \text{weight of 225 meter skein in grams} \times 40$$

STRENGTH

(*A*) *Preferred Method*

Test Skeins.

23. One skein from each of the ten spools, cops, tubes, cones or skeins drawn for a sample shall be prepared as described in Sections 14 and 15. The number of turns in these strength skeins shall be as specified in Table I. For sizes which require 200 ends, ten of the sizing skeins may be used if desired.

TABLE I

DENIER OF RAYON	NO. OF TURNS IN STRENGTH SKEIN
1 - 50 denier	400
51 - 75 "	200
76 - 120 "	150
121 - 200 "	100
Over 200 "	50

Conditioning.

24. After conditioning for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.) these ten skeins shall be separately broken on an automatic power yarn tester of inclination balance type of 25 kg. (55 lb.) or 50 kg. (110 lb.) capacities. The lower capacity shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When yarns break above this mark the higher capacity of testing machine shall be used.

Apparatus. 25. The machine shall be equipped with an automatic charting device to record stretch at any load.

26. Any tendency to friction, backlash, or play in the recording device, lower jaw, or screw, shall be overcome as far as practicable by counter balancing.

Jaws. 27. Clamps for holding the 200-end test skein shall consist of flat metallic jaws. These shall be covered with one layer of rubber tire tape which shall press directly against the specimen. One gripping surface shall be hinged or swiveled and the other shall be rigidly connected to the frame of the jaw. The pressure between the jaws shall be secured by any suitable mechanical device so constructed as to grip the yarns firmly before the testing load is applied and prevent visible slipping during the progress of the test.

Procedure. 28. The initial distance between jaws shall be 10 cm. (4 in.). The skein to be tested shall first be clamped in the upper jaws, spread out evenly so that the ends are parallel, forming a ribbon approximately $\frac{3}{8}$ to $\frac{3}{4}$ in. in width. The rayon shall then be drawn down through the lower jaws and spread out to make a band of equal width, pulled just taut and clamped.

Speed of Jaw. 29. The pulling jaw shall travel at a speed of 6 in. per minute.

One test shall be made on each of the 10 skeins prepared as in Section 23 and the average of these 10 tests shall be the strength.

(*B*) *Alternate Method*

Procedure, Alternate Method. 30. Five single strands from each of 10 spools, cops, tubes, cones, or skeins, shall be broken after conditioning the skeins for three hours and any other form of package for 12 hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.). A single strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used.

Strength. 31. The average of 50 tests shall be the tensile strength.

TWIST

Twist. 32. The twist shall be determined on any standard twist tester with jaws set 10 in. apart. The yarn shall be clamped in the jaws under a definite tension by attaching weights. The tension to be used shall approximate a value to be determined by the following formula:

$$\text{Tension in grams} = \frac{\text{Specified denier}}{30}$$

Example.—**The weight for 150 denier rayon would be** $\frac{150}{30} = 5$ **g.**

33. The specimen of yarn for twist determination shall be drawn from the side of the package instead of over the end in order to avoid changing the twist. **Specimen.**

34. Two tests, from each of five spools, cops, tubes, cones or skeins, shall be made and the average of these ten tests calculated to turns per inch shall be the twist. **Calculation.**

MOISTURE REGAIN

35. The standard moisture regain of nitro-cellulose, viscose and cuprammonium rayons shall be 11 per cent of the dry weight. **Moisture Regain.**

36. The standard moisture regain of cellulose-acetate rayons shall be 6.5 per cent of the dry weight.

TENTATIVE SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR TUBULAR SLEEVING AND BRAIDS[1]

A.S.T.M. Designation: D 354 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.

Scope. 1. These specifications cover the tolerances and test methods for fabric tubular sleeving, including braid.

TOLERANCES

WALL THICKNESS

Wall Thickness. 2. The wall thickness of sleevings and braids shall not vary from that specified by more than the following amounts:

	PERMISSIBLE VARIATIONS	
WALL THICKNESS, IN.	SLEEVING WITH ONE END PER CARRIER	SLEEVING WITH MORE THAN ONE END PER CARRIER
Up to and including 0.010	±0.001 in.	±0.002 in.
Over 0.010 and including 0.020	±0.0015 in.	±0.003 in.
Over 0.020	±0.002 in.	±0.004 in.

INSIDE DIAMETER

Inside Diameter. 3. The inside diameter of sleevings and braids shall not vary from that specified as nominal by more than the following amounts:

NOMINAL INSIDE DIAMETER, IN.	PERMISSIBLE VARIATIONS
Up to and including $\frac{3}{16}$	$+\frac{1}{64}$ in.
Over $\frac{3}{16}$ and including $\frac{3}{8}$	$+\frac{1}{32}$ in.
Over $\frac{3}{8}$	$+\frac{1}{16}$ in.

CARRIER

Carrier. 4. The number of carriers shall be not less than specified.

Ends on Bobbin. 5. The ends on the bobbin shall not exceed the number specified.

Size of Yarn. 6. The size of yarn in singles shall not vary more than 5 per cent above or below the specified size.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, **Box 28, East Side Station, Providence, R. I.**

WEIGHT

7. The weight of the sleeving or braid shall be calculated in yards per pound and in no case shall the yardage be less than that specified. **Weight.**

IMPERFECTIONS

8. All knots and imperfections are objectionable and shall be held to a minimum. Sleeving or braid containing more than 2 knots and 4 imperfections in any 5-lb. bundle will not be considered satisfactory and continued offense in this respect shall be a basis for rejection. **Imperfections.**

METHODS OF TESTING

WALL THICKNESS

9. The thickness of the wall shall be determined by inserting a mandrel of the nominal inside diameter of the sleeving or braid in the sample and measuring the outside diameter with a hand micrometer having anvil faces $\frac{7}{16}$ to $\frac{1}{2}$ in. in diameter. By subtracting the mandrel diameter from the overall measurement and dividing by two, the wall thickness is secured. **Wall Thickness.**

10. At least ten measurements of wall thickness shall be made on the samples used for weight determination and the average and range of thickness recorded. **Number of Measurements.**

INSIDE DIAMETER

11. The inside diameter of sleeving or braid shall be determined by the use of a mandrel of the specified diameter and having a hemispherical end. The mandrel shall be at least 6 in. in length. When a sample of the sleeving approximately 6 in. long is taken, a length of at least 3 in. when held firmly in the palm of the hand shall slide freely on the mandrel without disturbing the construction due to forcing the sample onto the mandrel. In sleeving of nominal diameter up to and including $\frac{3}{8}$ in., a mandrel $\frac{1}{64}$ in. over the nominal diameter shall just enter the sleeving; in sleeving over $\frac{3}{8}$ in. in nominal diameter a mandrel $\frac{1}{32}$ in. over the nominal diameter shall just enter the sleeving. **Inside Diameter.**

12. Inside diameter measurements shall be made on the samples selected for weight determinations. **Samples for Test.**

CARRIERS

13. The number of carriers shall be determined by cutting the sample at right angles to the axis of the sleeving and counting the total number of ends and dividing by the average number of ends per bobbin. **Carriers**

Samples for Test. 14. Carrier determinations shall be made on the samples used for making inside diameter measurements.

Ends on Bobbin. 15. The ends on the bobbin are the "number of ends up" or the number of ends in each web or tape. Ends on bobbin determinations shall be made at the time the carrier determinations are made.

Size of Yarn. 16. In determining the size of yarn an assorting yarn balance or similar device shall be used. It will be necessary to carefully ravel individual ends from the braid and from these the size will be computed automatically by the testing device.

Samples for Test. 17. Size of yarn shall be determined on the samples used for weight determinations.

WEIGHT

Weight. 18. A sample approximately $1\frac{1}{4}$ yd. in length shall be measured off while the sleeving or braid is laid flat on a smooth surface. The sample shall then be suspended vertically from a clamp gripping the full width of the sample and a 2-oz. weight shall be suspended from the lower end. The sample shall be allowed to remain under these conditions approximately 10 minutes and then a 1-yd. length shall be measured off and cut from the suspended sample. This length shall then be weighed and the yards per pound calculated.

Number of Determinations. 19. Not less than three weight determinations shall be made per shipment. Samples shall be removed from different bundles and the average of the three determinations shall indicate the average of the shipment involved.

IMPERFECTIONS

Imperfections. 20. The number of knots or imperfections shall be determined on any bundle by a visual examination.

NUMBER OF TESTS

Number of Tests. 21. From each shipment of sleeving or braid at least three bundles shall be selected and tests shall be made on lengths cut from each bundle. Failure of the first samples selected to conform to requirements of these specifications will necessitate the selection of a second set of bundles for a second test.

Referee Conditions. 22. In case of dispute, tests shall be made under standard conditions as defined in Section 3 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1102.

TENTATIVE METHODS OF TENSION TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 8 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1924; Revised, 1925, 1927, 1932.

Scope. 1. These methods are intended to cover the tension testing of metallic materials.

Definition of Terms. 2. The definitions of terms relating to tension testing in the Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6)[2] and in the Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T)[3] of the American Society for Testing Materials shall be considered as applying to the terms used in these methods of tension testing.

Apparatus and Speed of Testing

Testing Machine Calibration. 3. Testing machines used for tension testing shall conform to the requirements of the Standard Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4) of the American Society for Testing Materials.[4]

Speed of Testing. 4. The pulling speed has a marked influence on the tensile properties shown by materials tested, an increase in speed increasing the values found for yield point and tensile strength. The speed of head of the testing machine shall be such that the load can be accurately weighed.

5. In determining yield strength, the cross-head speed for the 2-in. gage length shall not exceed 0.125 in. per minute.

Wedge Grips. 6. Testing machines usually are equipped with wedge grips. Those wedge grips, irrespective of the type of testing machine, may be referred to as "the usual type of" wedge grips. The usual type of wedge grips generally furnish a satisfactory means of gripping long bars of ductile metal and for the flat plate test specimens shown in Fig. 6. When using grips of any kind, care shall be taken that the axis of the test specimen is located in the center line of the head of the testing machine and that the liners used behind wedge grips are of the proper thickness. Any defect in a testing machine which may cause non-axial application of load should be corrected immediately. For short specimens and for specimens of many materials, the usual type of grips is not a satisfactory means of holding test specimens. Usually it is necessary to use machined test specimens and to use a special means of gripping to insure that the specimens when under load, shall be as nearly as possible in uniformly distributed pure axial tension.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of the Technical Committee on Mechanical Testing of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

[2] 1930 Book of A.S T.M. Standards, Part I, p. 932.

[3] See p. 967.

[4] 1930 Book of A.S.T.M. Standards, Part I, p. 914.

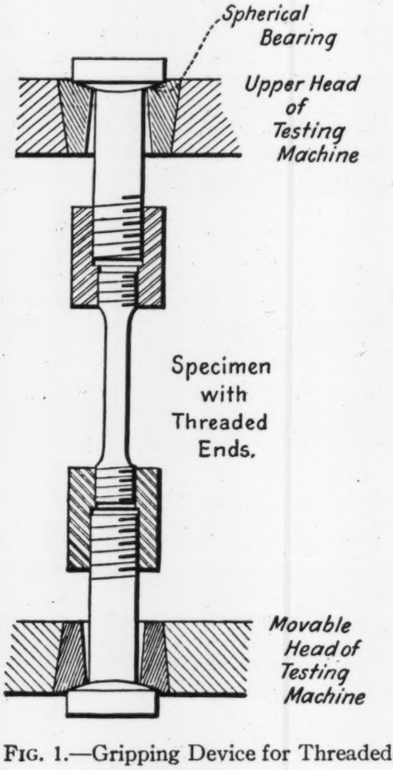

Spherical Bearing
Upper Head of Testing Machine
Specimen with Threaded Ends.
Movable Head of Testing Machine

Fig. 1.—Gripping Device for Threaded-End Specimens.

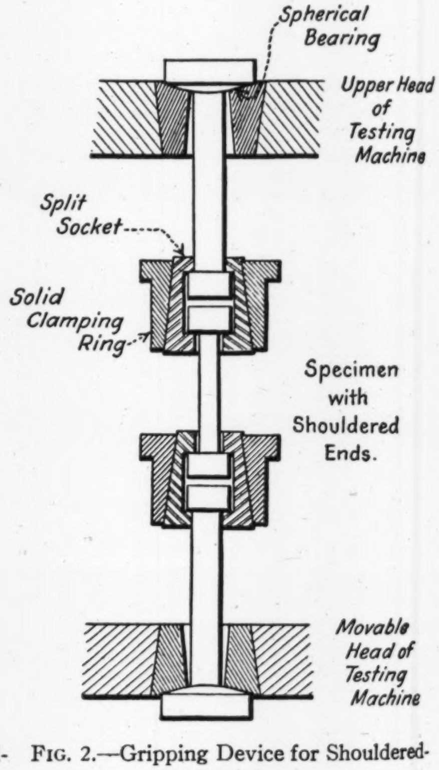
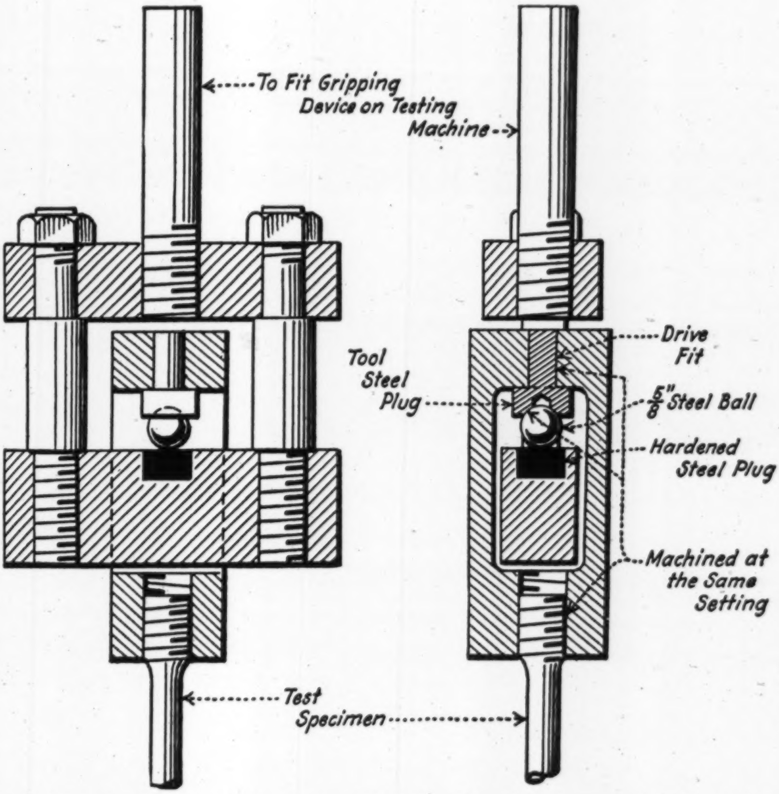

Spherical Bearing
Upper Head of Testing Machine
Split Socket
Solid Clamping Ring
Specimen with Shouldered Ends.
Movable Head of Testing Machine

Fig. 2.—Gripping Device for Shouldered-End Specimens.

Grips for Threaded and Shouldered Specimens and Brittle Materials.

7. A schematic diagram of a gripping device for threaded-end specimens is shown by Fig. 1, while Fig. 2 shows a device for gripping specimens with shouldered ends. Both of these gripping devices

shall be attached to the heads of the testing machine through spherical-seated bearings. The distance between spherical bearings should be as great as is feasible. For brittle materials, even the spherical-seated bearings shown in Figs. 1 and 2 are not always effective in avoiding bending stresses on the specimen. The gripping device shown in Fig. 3 has proved satisfactory for testing such specimens and is satisfactory for any machined tension test specimen.


To Fit Gripping Device on Testing Machine
Tool Steel Plug
Drive Fit
$\frac{5}{8}$" Steel Ball
Hardened Steel Plug
Machined at the Same Setting
Test Specimen

The gripping device is shown as used with threaded end specimens. A similar device fitted with split sockets would be used with shouldered specimens.

FIG. 3.—Gripping Device for Brittle Materials or Machined Test Specimens.

Grips for Sheet Materials. 8. The self-adjusting grips shown in Fig. 4 have proved satisfactory for testing sheet materials which cannot be tested satisfactorily in the usual type of wedge grips.

Grips for Wire. 9. For tests of specimens of wire which are liable to be cut at the edges of the usual type of wedge grips, this cutting has been found to be largely eliminated by grips of the form shown in Fig. 5.

TEST SPECIMENS FOR VARIOUS MATERIALS

Test Specimens.

10. (*a*) The test specimens used for making tension tests shall be determined by the material being tested. The description of the standard test specimens to be used for various materials is given below under separate sections devoted to specific materials.

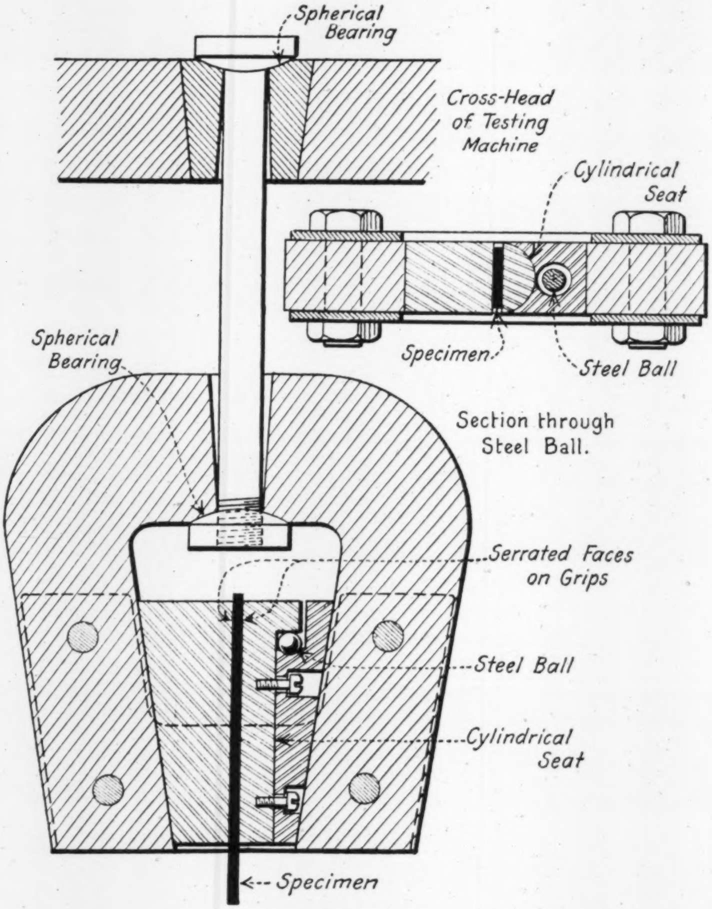

Spherical Bearing
Cross-Head of Testing Machine
Cylindrical Seat
Spherical Bearing
Specimen
Steel Ball
Section through Steel Ball.
Serrated Faces on Grips
Steel Ball
Cylindrical Seat
Specimen

FIG. 4.—Gripping Device for Sheet Materials.

(*b*) In recommending these specimens for use in tension tests, it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material. It is, however, recommended that wherever it is feasible the specimens recommended be used.

Finish of Specimens.

11. The reduced sections of all specimens shall be machined in such a manner as to avoid leaving severe machining strains in the material. It is essential that the reduced section and the ends of the specimen be symmetrical with respect to the longitudinal axis of the specimen. In no case should the assymmetry of the tension test specimen exceed 0.01 in. For all specimens of flat metallic materials, both for sheet and for thick plate, it is important to so machine the specimen as to avoid the condition shown in Fig. 8.

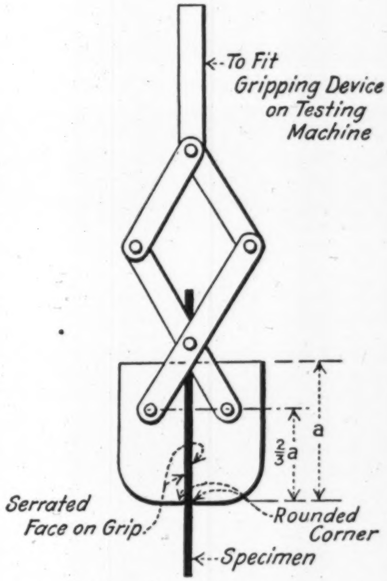


FIG. 5.—Gripping Device for Wire.

12. All specimens used for tension tests shall be finsihed so that the surfaces are smooth and free from nicks and tool marks. All ragged edges shall be smoothed.

Plate, Shape and Flat Material.

13. The tension test specimen shown in Fig. 6 is recommended for plate, shape and flat material having a thickness of $\frac{1}{4}$ in. or over.[1] The thickness, *t*, of the specimen shall be that of the material tested.

NOTE.—When it is desired to use a specimen with a gage length of less than 8 in., the general proportions of Fig. 6 are recommended. Specimens with a gage length of 2 in. and a width of $1\frac{1}{2}$ in. are occasionally used. In all cases, the gage length shall be laid off to an accuracy of ± 0.01 in. When it is not convenient to machine specimens to the standard shape shown in Fig. 6, specimens may be used with edges machined parallel for the entire length of the specimen. If such specimens are machined with a tool cutting across the edges of the specimen, it is important that the transverse tool marks be removed before the specimen is tested.

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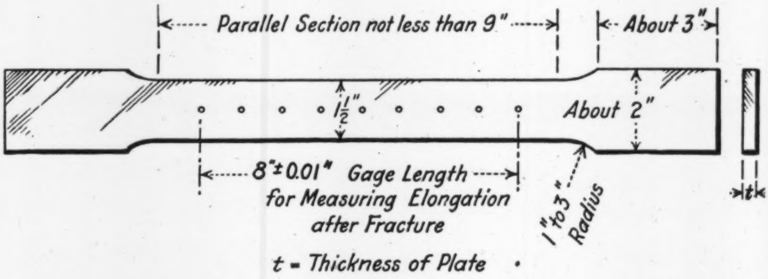
[1] Attention is called to the fact that two types of specimens are applicable for material $\frac{1}{4}$ in. in thickness, the plate specimen shown in Fig. 6 and the sheet metal specimen shown in Fig. 7.

For thick plate material, it is usually preferable to use a specimen of the type described in Sections 15 to 17, inclusive, rather than to use a specimen the full thickness of the plate.

Sheet Material and Wrought Material 0.01 to 0.25 in. in Thickness.

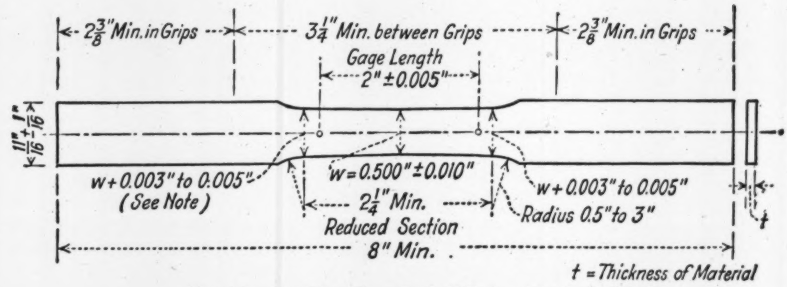
14. For tension tests of wrought ferrous and non-ferrous metal in the form of plate, sheet, flat wire,[1] strip,[1] band,[1] and hoop[1] without respect to width,[1] length, grade or method of manufacture, and having a thickness from 0.01 to 0.250 in., the test specimen described in Paragraph (*a*) and (*b*) is recommended.

NOTE.—This specimen may also be used in tests of material cut from tubing.


Parallel Section not less than 9"
About 3"
$1\frac{1}{2}$"
About 2"
8" ± 0.01" Gage Length for Measuring Elongation after Fracture
1" to 3" Radius
t
t = Thickness of Plate

Width is subject to a tolerance of ± 0.01 in.

FIG. 6.—Tension Test Specimen for Plate Material.


$2\frac{3}{8}$" Min. in Grips
$3\frac{1}{4}$" Min. between Grips
$2\frac{3}{8}$" Min. in Grips
Gage Length 2" ± 0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005" (See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
$2\frac{1}{4}$" Min. Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 7.—Standard Tension Test Specimen for Sheet Metals.

(*a*) *Specimen Blank.*—The specimen blank shall be cut from the material to be tested, having its length in such direction relative to the material as may be specified. The specimen blank shall conform to the dimensions shown in the following table:

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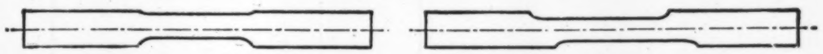
[1] It is to be noted that the recommended specimen cannot be used for flat wire, strip, band, or hoop material whose width is less than the end width of the specimen itself.

METHOD OF CUTTING LONG EDGES OF BLANK	NOMINAL THICKNESS OF MATERIAL, IN.	MINIMUM WIDTH OF BLANK, IN.
Sheared..................	Up to ⅛, inclusive	¾
Sheared..................	Over ⅛ to ¼, inclusive	1
Sawed[a]..................	Up to ¼, inclusive	¾

[a] Or otherwise machined without severely straining the metal.

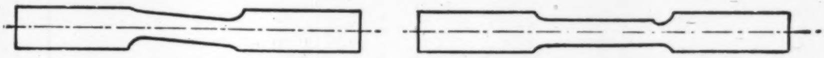
Blanks cut with a torch shall not be used unless all metal affected by such cutting is removed by machining.

(*b*) *Finished Test Specimen.*—Figure 7 shows the form of the finished specimen recommended for sheet metals.



(*a*) Ends not Symmetrical with Reduced Section.

(*b*) Two Sides of Reduced Section not Symmetrical.



(*c*) Ends not Parallel to Reduced Section.

(*d*) Narrow Width Due to "Hogging in" of Cutter.

FIG. 8.—Common Errors in Preparation of Plate or Sheet Metal Test Specimens.

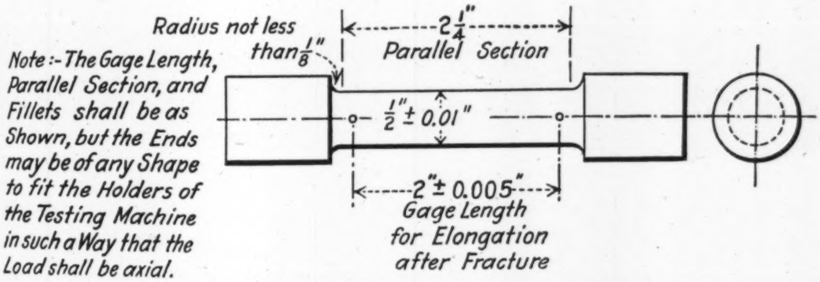

Radius not less than 1/8"
2 1/4"
Parallel Section
Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

FIG. 9.—Standard 2-in. Tension Test Specimen.

Test Specimen for General Use in Testing Metals.

15. (*a*) The tension test specimen shown in Fig. 9 is recommended for general use in testing metals. The gage length for measuring elongation after fracture is 2 in. The radius shall be not less than ⅛ in., a larger radius is preferable and for some materials necessary.

(*b*) A slight taper of the "parallel section" not to exceed a maximum of 1 per cent of the diameter within the gage length, similar to that shown in Fig. 7 for sheet materials, is desirable for all tension test specimens.

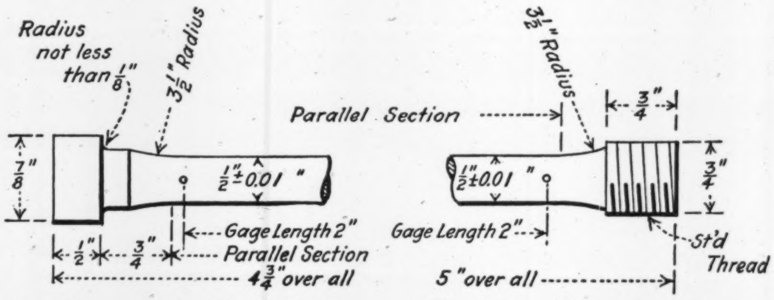
Ends of Specimens.

16. The shape of the ends of the specimen shown in Fig. 9 is not specified. For specimens of brittle materials, it is desirable that

the diameter of the specimen be changed gradually along its length from the minimum section at the gage length to the diameter at the ends. Figure 10 shows two forms of end of specimen which have given satisfactory results in tests of brittle materials.

17. When it is necessary to cut specimens from material (other than plate, shape and flat material) which is of such size that the specimen shown in Fig. 9 cannot be used, it is recommended that a specimen with dimensions proportional to those shown in Fig. 9 be used and that the specimen be made as large as feasible. In any such small-size specimen, it is especially important that the gage length for measuring elongation be four times the diameter of the specimen.

Wire and Rod. 18. Tension test specimens of wire and rod are frequently of the full size as fabricated. It is suggested that the upper limit of size for wire be considered as $\frac{1}{2}$ in. in diameter. For the measurement of elongation of wire or rod $\frac{1}{2}$ in. in diameter or less which is tested in the full size, a gage length of 10 in. is frequently used.



(*a*) Specimen with shouldered ends. (*b*) Specimen with threaded ends.

FIG. 10.—Form of Ends for Threaded-and Shouldered-End Specimens.

Pipe and Tubing. 19. Tension test specimens of pipe and tubing are frequently of full size as manufactured except where the tube in full section exceeds the capacity of the testing machine either with regard to the load required or with regard to suitable gripping arrangements. In order to grip the ends of tubular specimens, suitable snug-fitting metal plugs shall be inserted in the ends of the tube. The plugs shall be long enough to permit the jaws to grip that part of the tube in which the plugs are inserted, but the plugs shall not extend into that part of the tube upon which the elongation is measured. Figure 11 shows a suitable metal plug, and a diagram showing the location of plugs in a specimen and the proper location of a specimen in the heads of a testing machine.

Small Tubing.

20. All small tubing, particularly sizes 1 in. outside diameter and less shall be tested in accordance with Section 19. This method is also suitable for tubing of larger size up to the capacity of the testing machine.

Large Tubing.

21. (*a*) For large diameter heavy-wall tubing, which cannot be tested in full size, the test specimen shown in Fig. 6 may be used by cutting and flattening a suitable strip from the tube.

(*b*) If desired, test specimens similar to that shown in Fig. 6 may be made on the curved strips cut from the tube. These strips shall be tested, without flattening, in special curved grips made to fit the curvature of the tube.

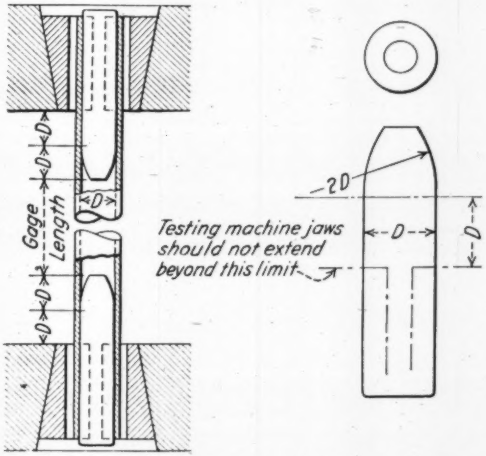


FIG. 11.—Metal Plugs Used for Testing Tubing, Location of Plugs in Test Specimen of Tubing and Proper Location of Specimen in the Heads of a Testing Machine.

Large Heavy-Wall Tubing.

22. Where the wall of the tubing is $\frac{3}{4}$ in. in thickness or greater, it is recommended that suitable strips be cut and the test specimen shown in Fig. 9 be used. The diagram, Fig. 12, shows the location of the tension test specimen to be cut from large diameter heavy-wall tubing.

Large Thin-Wall Tubing.

23. For large diameter thin-wall tubing which cannot be tested full size, it is recommended that the specimen shown in Fig. 7 be used. The diagram, Fig. 13, shows the location of the tension test specimen to be cut from large diameter thin-wall tubing.

NOTE.—In some instances, annealed low-carbon steel or iron tubing tension test specimens have been made by flattening the ends of a length of the tubing and then gripping the flattened ends in flat wedge grips for testing. Such procedure has been used satisfactorily for production control tests.

Measurement of Dimensions of Test Specimens.

24. The dimensions of cross-section of tension test specimens shall be preferably measured by means of a measuring instrument reading to 0.5 per cent of the dimensions measured and in any case to at least 0.001 in. The stress shall be computed on the basis of the minimum cross-section as determined by measurement.

NOTE.—It will be noted that the tolerance for diameter of specimens shown in Fig. 9 permits the use of specimens 0.505 in. in diameter.

DETERMINATION OF PROPORTIONAL LIMIT, ELASTIC LIMIT, YIELD STRENGTH, YIELD POINT AND TENSILE STRENGTH

25. The term "elastic limit" is defined as follows:

Elastic Limit.—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

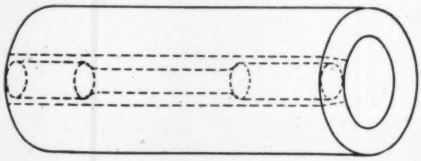


FIG. 12.—Location of Tension Test Specimen to be Cut from Large Diameter Heavy-Walled Tubing.

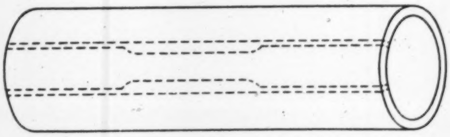


FIG. 13.—Location of the Tension Test Specimen to be Cut from Large Diameter Thin-Walled Tubing.

NOTE.—It is a matter of experience with many materials, especially with many metallic materials, that using ordinary methods of testing, the values found for elastic limit by means of observations of permanent deformation (set) after release of stress do not differ widely from the values found for proportional limit, the latter being defined as:

Proportional Limit.—**The greatest stress which a material is capable of developing without a deviation from the law of proportionality of stress to strain (Hooke's Law).**

Since the determination of proportional limit is much more readily made than is the determination of elastic limit, it is customary to accept the proportional limit as equivalent to the elastic limit for such materials, and hence the proportional limit is frequently called the "proportional elastic limit."

In certain specifications of the Society, the term "Elastic Limit" is used to designate a value obtained by a test method which does not involve the release of stress during a test, but which does involve the determination of a limiting load at which there occurs an appreciable increase in rate of strain

with respect to stress. This method may determine, for some materials, a satisfactory value of the proportional elastic limit, but the property termed "Yield Strength" determined by the "set method" as described below, is felt to be a more widely satisfactory and significant measure of the desired strength property of the material.

26. The term "yield strength" is defined as follows:

Yield Strength.—The stress at which a material exhibits a specified limiting permanent set.

NOTE.—It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member *begins*. Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

The limit of usefulness of many materials, especially metals, in members subjected to approximately static loading at ordinary temperatures is therefore determined by a measurable value of plastic yielding of the material above which the material is considered to be damaged and below which the damaging effects are considered to be negligible.

The following methods are recommended for determining the yield strength of a material:

1. For material that has a "sharp-kneed" stress-strain diagram and hence exhibits at a certain stress the special characteristic of yielding without increase in stress. Two satisfactory methods are in use:

(*a*) *The "Drop of the Beam" Method.*—In this method the load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at approximately a steady rate. When the yield strength of the material is reached the increase of load stops, but the operator runs the poise a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device, there is a sudden halt of the load-indicating pointer corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield strength. This method of determining the yield strength requires only one man to conduct a test.

(*b*) *Total Strain Method Using Dividers.*—This method is frequently called the "dividers method." In this method an observer with a pair of dividers or other suitable apparatus, watches for visible elongation between two section marks on the specimen. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield strength.

Note on Yield Point.—The above two methods determine what is usually called the yield point which is commonly defined as follows:

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

It should be noted that only materials that exhibit this unique phenomenon of yielding have a yield point. The term yield point should not be used in connection with material whose stress-strain curve in the region of yield is a smooth curve of gradual curvature.

2. For material whose stress-strain diagram in the region of yield is a smooth curve of gradual curvature.

(*a*) *The Set Method.*—This method can be used, if desired, for materials having "sharp-kneed" stress-strain diagrams, but is especially adapted to materials whose stress-strain diagram in the yield range is a smooth curve of gradual curvature.

For nearly all materials, if at any point on the stress-strain diagram such as *r* in Fig. 14, the load is released the diagram for decreasing load will follow a line, *rm*, approximately parallel to the initial portion, *OA*, of the diagram for increasing load. *Om* will then give the approximate value of the permanent set after the release of the stress *OR*. The value of this set is given in percentage of original gage length. Thus to determine the yield strength by the "set method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn. Then with the stress-strain diagram (Fig. 14) lay off *Om* equal to the specified value of the set, and draw *mn* parallel to *OA* and thus locate *r*, the intersection of *mn* with the stress-strain diagram. Draw *Rr* parallel to the *X* axis and then *OR* gives the value of the yield strength.

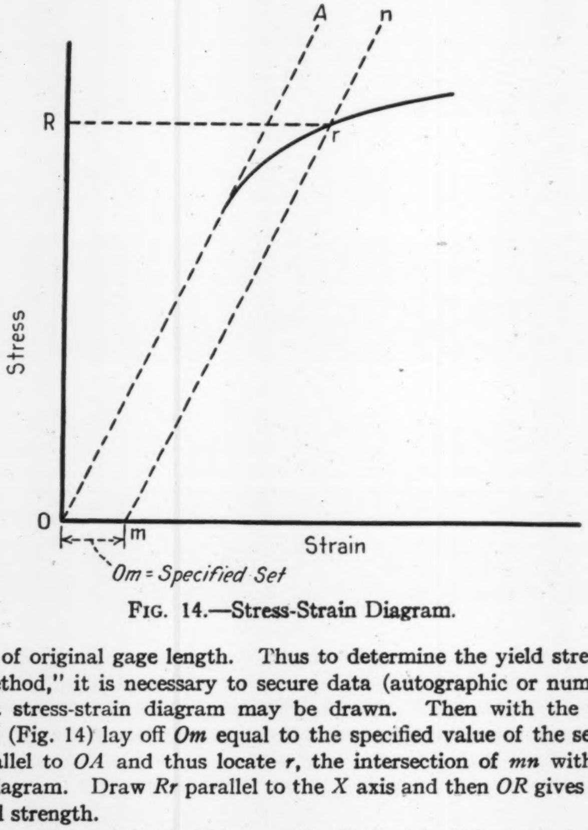


FIG. 14.—Stress-Strain Diagram.

In reporting values of yield strength obtained by this method, the specified value of "set" used should be stated in parentheses after the term yield strength. Thus:

Yield strength (set = 0.1 per cent) = 52,000 lb. per sq. in. indicates that at a stress of 52,000 lb. per sq. in. the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.[1]

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[1] A value of 0.20 per cent of the gage length has been used rather widely for metals.

In using this method, an extensometer reading to 0.0001 in. per inch of gage length would be sufficiently sensitive for most materials. It will be observed that the elastic limit and proportional limit are special values of the yield strength in which the specified limiting set is not measurable with the instruments used and hence is considered to be zero.

(*b*) *Approximate Method Without Stress-Strain Diagram.*—For tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specified permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen, when this total strain is reached, is the value of the yield strength. The total strain can be obtained satisfactorily by use of an extensometer or in some cases by use of dividers particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line and if it is observed through a reading glass. But it is recommended that this approximate method be used only after agreement between producer and consumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the set method to settle any misunderstandings.

Tensile Strength.

27. The term "tensile strength" is defined as follows:

Tensile Strength.—The maximum tensile stress which a material is capable of developing.

NOTE.—In practice, it is considered to be the maximum stress developed by a specimen representing the material in a tension test carried to rupture, under definite prescribed conditions. Tensile strength is computed from the maximum load carried during a tension test and the original cross-sectional area of the specimen.

The conditions that must be prescribed in a tension test of metallic materials are the form of specimen, the method of gripping the specimen, and the rate of application of load. These are covered in foregoing sections. No further detailed discussion of methods of determining tensile strength is necessary, as there is involved merely the observing and the recording of the maximum load carried by the specimen during the test.

PLOTTING STRESS-STRAIN DIAGRAMS

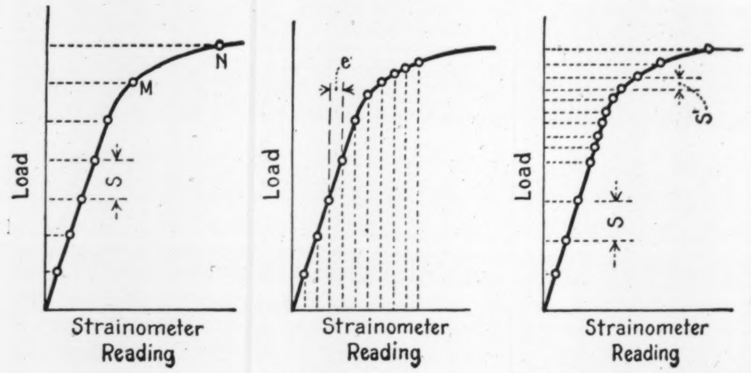
Stress-Strain Diagram.

28. A stress-strain diagram is a diagram plotted with values of stress as ordinates and values of strain as abscissas.

NOTE.—The use of the term "stress-strain diagram" is frequently extended to cover diagrams plotted with values of applied load, or applied moment, as ordinates and with values of stretch, compression, deflection, or twist as abscissas.

Stress-strain diagrams are in some cases drawn directly by an autographic attachment to the testing machine. A more usual method of procedure consists in taking a series of load readings (from the balanced scale beam of the testing machine) with corresponding readings of the strain-indicating apparatus. The term "strainometer reading" will be used to denote the reading of the strain-measuring instrument. From these readings, or from values computed from them, there is plotted a diagram with stress-indicating values (load or stress) as ordinates, and strain-indicating values (elongation or strain) as abscissas. In planning such a test it is necessary to decide on the increment of load or the increment of reading of strainometer to be used between successive readings.

In Fig. 15 are shown three typical stress-strain diagrams. The material for all three tests is the same, and the test specimens are all of the same size, so that the diagrams should be the same. The diagram shown in Fig. 15 (*a*) is plotted from points determined by taking increments of load (*S*). In this diagram it is seen that owing to the shape of the curve, data for locating points between *M* and *N* are lacking. That particular portion of the curve (the "knee" of the curve) is the part for which it is especially desirable to locate several points on the diagram.



(*a*) With Equal Increments of Stress.
(*b*) With Equal Increments of Strain.
(*c*) With Two Values of Increments of Stress.

FIG. 15.—Illustrating Three Methods of Plotting Load-Deformation Curves.

In Fig. 15 (*b*) is shown a diagram plotted from points determined by taking increments of strainometer reading (*e*). It will be noted that for this diagram there are located several points near the knee of the curve, and the shape of the diagram in this important region is much more definitely determined than for the curve shown in Fig. 15 (*a*).

The custom of choosing increments of load rather than increments of strainometer reading is quite common in tests of materials and is followed because, in general, it is easier to compute increments of load than it is to compute increments of strainometer reading. An estimate of the load necessary to stress the specimen up to the knee of the curve is made and some fraction (frequently one-tenth) of this value is taken as an increment. The computation of the corresponding increment of strainometer reading is more complicated.

Sometimes the practice is followed of applying a few increments of load as determined above, and then applying load in much smaller increments (S') until the knee of the curve is passed. Figure 15 (*c*) shows a diagram obtained in this manner. This method involves a marked increase in the number of readings necessary for a test and with unknown material there is always some danger that the knee of the curve will be reached before the use of small increments of load is begun.

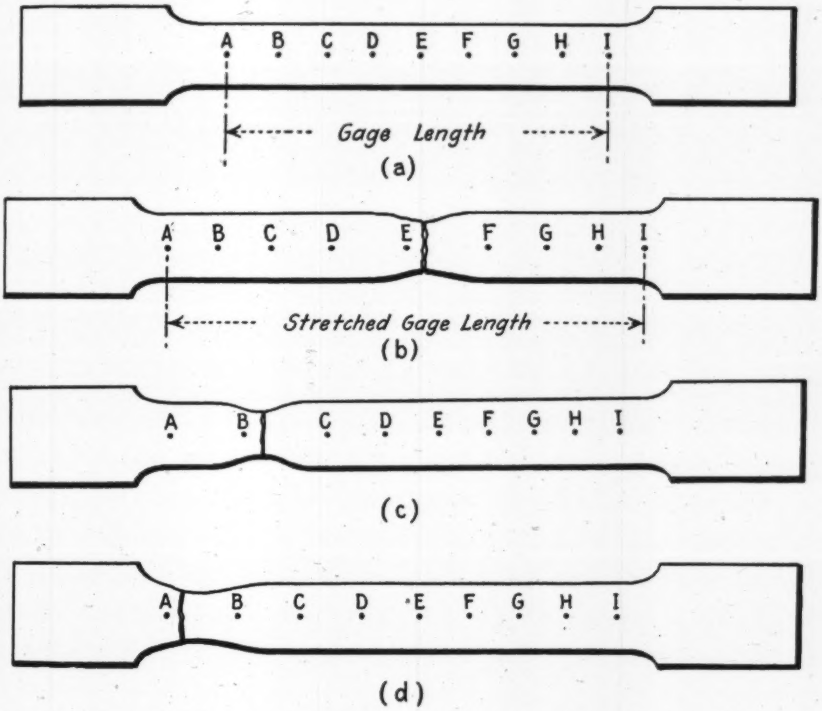


FIG. 16.—Method of Marking Gage Length for Measuring Elongation After Fracture.

The following method of choosing increments for a test is suggested: Estimate the load corresponding to the knee of the stress-strain diagram and choose a value for increment of load about one-tenth of this value. Apply this increment of load (S) once and note the corresponding change of reading for the strainometer (*e*). Then for the remainder of the test, use for the increment of strainometer reading a value which corresponds to some convenient interval on the scale of the strainometer, and which is approximately equal to (*e*).

THE MEASUREMENT, AFTER FRACTURE, OF THE ELONGATION AND THE REDUCTION OF CROSS-SECTION OF TENSION TEST SPECIMENS

Elongation. 29. The measurement of the elongation after fracture of tension test specimens can be made with sufficient accuracy by means of a pair of dividers and a scale. The elongation should not be reported for any tension test specimen which breaks outside the middle third of the gage length.

NOTE—If only a few specimens are furnished for testing it is recommended that in marking the gage length for measuring elongation after fracture it be divided into eight parts, and that if a specimen breaks inside the gage length but outside the middle third of the gage length the requirement in the foregoing paragraph be waived, and the elongation be measured and reported as follows:

(1) If the specimen breaks in the middle half of the gage length (between *C* and *G*, Figs. 16 (*a*) and (*b*)) the elongation is measured directly over the stretched gage length (Fig. 16 (*b*)).

(2) If the specimen breaks between *A* and *C* (or between *G* and *I*) but nearer *B* than *A* (or nearer *H* than *I*), as shown in Fig. 16 (*c*) the elongation from *A* to *C* (or from *G* to *I*) is measured, and to this is added *twice* the measured elongation from *C* to *F* (or from *D* to *G*).

(3) If the specimen breaks within one-half a division of an end gage mark (see Fig. 16 (*d*)) the elongation from *A* to *E* (or from *E* to *I*) is measured and multiplied by 2.

The above method can be applied to specimens with any gage length, and to turned specimens as well as flat specimens.

This method is not applicable to brass specimens.

Reduction of Area. 30. The measurement of reduction of the dimensions of the cross-section of a tension test specimen may be made by the direct measurement with a micrometer of the smallest section of the fractured specimen. For round specimens this measurement can usually best be made by holding the broken pieces together in a vise or between centers and measuring the average diameter of the smallest cross-section by means of a micrometer fitted with points so shaped that they will come in contact with the specimen at its smallest diameter.

The reduction in area is calculated as the percentage reduction, based on the original area.

TENTATIVE METHODS OF ROCKWELL HARDNESS TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 18 - 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1932.[2]

The Rockwell hardness tester is essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under certain arbitrary fixed conditions of test. The penetrator may be either a steel ball or a diamond cone. The hardness is expressed as a number which is obtained by subtracting the penetration from an established constant. A minor load of 10 kg. is first applied which causes an initial penetration which sets the penetrator on the material holding it in position. The dial is set at zero on the black-figure scale, and the major load is applied. This major load is customarily 60 kg. or 100 kg. when a steel ball is used as a penetrator, but other loads may be used when found necessary, and 150 kg. when a diamond cone is employed. The ball penetrator is $\frac{1}{16}$ in. in diameter normally but other penetrators of larger diameter such as $\frac{1}{8}$ or $\frac{1}{4}$ in. may be employed for soft metals. A variety of loads and penetrators are thus provided and experience decides the best combination for use.

After the pointer comes to rest upon the application of the major load, the major load is then removed leaving the minor load still applied to the specimen. The difference in penetration between the major load and the minor load is then revealed by the dial.

APPARATUS

Rockwell Scales.

1. Two scales of hardness shall appear on the dial of the machine since two loads and two penetrators are employed. When scales other than those specified in Paragraphs (*a*), (*b*) and (*c*) are employed, the diameter or type of penetrator, the major load, and the scale used (whether red or black divisions) shall be reported. Other loads and penetrators may be employed but the loads and the penetrators that have been found to be the most useful and which have been adopted as standard are specified in Paragraphs (*a*), (*b*) and (*c*).

(*a*) *B Scale.*—The "B" scale or red divisions shall be used when a 100-kg. major load and a $\frac{1}{16}$-in. ball penetrator are employed.

(*b*) *C Scale.*—The "C" scale or the black divisions shall be used when a 150-kg. major load and the diamond cone penetrator are employed.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. R. Townsend, Chairman of the Section on Indentation Hardness Testing of Committee E-1 on Methods of Testing, Bell Telephone Laboratories, 463 West Street, New York City.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 11, 1932.

(*c*) *E Scale.*—For testing soft metals, the "E" scale is recommended. The E scale employs a $\frac{1}{8}$-in. ball penetrator, a minor load of 10 kg. and a major load of 100 kg. The dial shall be turned so that the pointer reads at "set" (or B-30) before applying the minor load. After the major load has been applied and removed, the hardness shall be read on the red scale.

(*d*) *F Scale.*—For materials of intermediate hardness the "F" scale is recommended. The F scale employs the $\frac{1}{16}$-in. ball penetrator, a minor load of 10 kg. and a major load of 60 kg. using the "B" scale or red divisions.

Penetrators. 2. The penetrator may be either a steel ball or a diamond cone. The steel ball penetrator shall ordinarily be $\frac{1}{16}$ in. in diameter but other penetrators of a larger diameter such as $\frac{1}{8}$ in. or $\frac{1}{4}$ in. may be employed for soft metals.

Anvil. 3. The anvil used for flat surface test pieces shall be a smooth and flat bearing surface for the material of about $\frac{3}{16}$ in. in diameter. It shall be hard enough so that no visible indentation is made when the thinnest material is tested.

Test Blocks. 4. It is recommended that the following test blocks be available for checking the Rockwell hardness tester. For the B scale employing the 100-kg. load and the $\frac{1}{16}$-in. diameter ball, and reading on the red figures, blocks constructed of brass or similar material and having a hardness of approximately B-15, B-30, B-55, B-65, B-80, B-90, and B-100 are used. For the C scale employing the diamond cone and 150-kg. load and reading on the black figures, blocks having a hardness of approximately C-20, C-50, and C-70 are commonly employed. These blocks may also be calibrated for the 60-kg. load with a $\frac{1}{16}$-in. diameter ball, and for the 150-kg. load with the $\frac{1}{16}$-in. diameter ball. For the C scale hardened steel blocks may be employed and for any other scales blocks made of suitable material to give the desired hardness range may be employed.

TEST SPECIMENS

Thickness of Specimen. 5. There is necessarily a limit to the thickness of metal that may be satisfactorily tested. For example, the practical limit of thickness for cold-rolled non-ferrous metals employing the $\frac{1}{16}$-in. diameter ball and the 100-kg. load is of the order of 0.020 in. Hardness readings taken on metal less than 0.020 in. in thickness give a higher reading than that obtained for metals of the same hardness but thicker. Material much thinner than 0.020 in. cannot be tested satisfactorily on the hardness tester. The same precautions apply to steel where the diamond cone is used. As a general rule the indentation should not show through the specimen and no material so thin as to cause indentation of the anvil shall be tested. Should damage to the anvil result in any instance the anvil shall be replaced. Anvils showing the least perceptible dent will give inaccurate results. All tests should be made on one thickness of metal. Irregularities of fit between more than one specimen will affect the result.

PROCEDURE

Procedure.

6. Before using the machine and each time the indenting tool is removed from its seat, the machine shall be operated several times on a piece of scrap material in order to firmly settle the penetrator, anvil, and moving parts of the machine. An average reading shall be made on at least one of the standard test blocks nearest to the hardness of material to be tested.

The test piece shall be placed on the anvil and the capstan screw elevated to bring the specimen against the penetrator. To apply the minor load of 10 kg. the capstan screw shall be continued to be elevated until the reference mark on the gage stem appears at the edge of the gage. At this point the pointer shall appear within ± 5 divisions of the zero on the black division scale at the top of the dial. If the elevating screw has been turned too far, the minor load shall be removed and a new spot selected for the test. The last movement of this screw must always be in such a direction as to elevate the specimen. After the minor load has been applied, the dial pointer shall be set at zero on the black-figure scale.

In applying the major load, the operating handle shall be allowed to move without interference until the major load is completely applied. This may be observed in two ways, (1) when the pointer suddenly slows down, or (2) watching the weight arm to see that it is completely free from the control of the dash pot. When the major load has been completely applied, the operating handle shall be immediately brought back to the latched position. This shall be accomplished in less than two seconds after the major load is completely applied. There must be no shock given to the machine in any way.

The Rockwell ball should occasionally be replaced by a new one and the operator should be on the lookout for any permanent deformation or roughness of the ball which will ordinarily be indicated by high readings on the standard test blocks.

All hardness data obtained with this method shall be prefixed by a letter showing whether the hardness value was determined on the "B" scale, the "C" scale, the "E" scale or the "F" scale.

ADJUSTMENT AND CALIBRATION OF ROCKWELL HARDNESS APPARATUS

Adjustments. 7. (*a*) *Dash Pot.*—The dash pot on the Rockwell tester shall be so adjusted that the operating handle completes its travel in from 5 to 10 seconds with no specimen on the machine and with the machine set up to apply a major load of 100 kg.

(*b*) *Index Lever Adjustment.*—The following tests (and adjustments, if necessary) shall be made as follows: Place a piece of material on the anvil and turn the capstan elevating nut to bring the material against the ball penetrator. Keep turning to elevate the material until the hand feels positive resistance to further turning, which will be felt after the 10-kg. minor load has been picked up and when the major load is encountered. When excessive power would have to be used to raise the work higher, take note of the position of the pointer on the dial, after setting the dial so that C-0 and B-30 are at the top. Then if the pointer stands between B-50 and B-70 no adjustment is necessary; if the pointer stands between B-45 and B-50, adjustment is advisable, and if the pointer stands anywhere else, adjustment is imperative. As the pointer revolves several times when the work is being elevated the readings mentioned above apply to that revolution of the pointer which occurs as the reference mark on the gage stem disappears into the sleeve. The object of the adjustment is to see that the elevation of the specimen to pick up the minor load shall not be carried so far as to cause even a partial application of the major load, which to make a proper test, shall be applied only through the release mechanism.

The adjustment of the index lever, if necessary, shall be made as follows: When the test piece is elevated until it starts to pick up the major load, loosen the lock nut of the screw through the index lever which carries at its lower end a small steel plate engaging the ball on the penetrator shaft, while using a small screw-driver to firmly hold the screw until after the nut is loose. Then turn the screw very slightly and note the result on position of the gage pointer which should be between B-60 to B-70 before reclamping the screw with its lock nut.

Calibration With Test Blocks. 8. In order to check the machine to determine if it is in good working order and giving standard readings test blocks shall be employed. In order for the results of two or more machines to check accurately, it is necessary that each machine be calibrated with these test blocks. Variations in readings due to adjustment, wear, or friction in the operating parts are liable to exist. A satisfactory method of making such tests is to first calibrate the test blocks by taking the minimum and maximum readings of three or more Rockwell machines that are known to be in good adjustment and use these readings as the correct calibration of the block. All other machines may then be adjusted until they agree with the readings of the test blocks. Since there is some variation in the material of which the test block is made, it is desirable to make at least five readings, one in the center and four readings, one in each corner of the block. In the case of the inspection of material between a producer and a consumer, the producer and consumer should agree upon the standard test block that is used to calibrate the machine.

In any instance the calibrated reading of the machine shall be employed and the corrections from the standard blocks applied. It is good practice to keep the Rockwell machines in agreement within 2 hardness numbers in the hard ranges and 4 hardness numbers in the soft ranges. Tests shall be made on standard test blocks before and after a given group of readings. The average reading of the machine on the test blocks before and after the group of tests shall be considered the average reading of the machine and the correction applied to this value.

PRECAUTIONS

Precautions.

9. (*a*) *Protection Against Vibration.*—If the bench or table on which the Rockwell tester is mounted is subject to vibration, such as felt in the vicinity of other machines, the tester should be mounted on a metal plate on sponge rubber at least 1 in. thick or any other type of mounting that will effectually eliminate vibration from the machine. Otherwise the pointer will penetrate farther into the material than when such vibrations are absent.

(*b*) *Cushioning of Latch.*—If, when the operating handle is being returned to its normal position, the latch operates with such a snap as to noticeably change the position of the dial pointer, felt or rubber washers should be placed under the trip mechanism in order to cushion this blow. If this snap is severe, difference in reading of several hardness numbers may result.

(*c*) The specimens employed for hardness determinations shall be prepared with some care. The surface oxidation shall be removed and this may be accomplished by rubbing lightly with a suitable abrasive and should sheet metal be employed special care should be taken with material that is curved. The concave side of the curved metal should face toward the penetrator. If such specimens are reversed an error will be introduced due to the flattening of the metal on the anvil.

(*d*) Specimens which have sufficient overhang so that they do not balance themselves on the anvil shall be properly supported.

(*e*) In testing cylindrical specimens, a V-notch anvil shall be used and the penetrator applied over the axis of the rod. The specimen shall lie flat in the V-notch anvil and directly in line with the penetrator.

(*f*) The penetrator and anvil should not be brought together without a test piece between them, otherwise the anvil will be indented and the ball flattened.

(*g*) The minor load shall be applied so that the pointer approaches within ± 5 divisions from top of the dial when the notch on the lower dial stem just comes in line with the edge of its sleeve.

(*h*) The dial gage plunger shall move free without appreciable change of friction in any position.

(*i*) The time of application of the major load shall be established and accurately adhered to when comparing results. As a general rule an interval of full application of the major load of not more than one second is best. For soft metals the penetration will "creep," causing variations as high as 10 hardness numbers. With such metals the operating lever should be brought back the moment it is seen that the major load is fully applied.

TENTATIVE DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING[1]

A.S.T.M. Designation: E 6 – 32 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1923; REVISED, 1924, 1925, 1930, 1932.

Elastic Limit.—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

NOTE.—It is a matter of experience with many materials, especially with many metallic materials, that using ordinary methods of testing, the values found for elastic limit by means of observations of permanent deformation (set) after release of stress do not differ widely from the values found for proportional limit, the latter being defined as:

Proportional Limit.—The greatest stress which a material is capable of developing without a deviation from the law of proportionality of stress to strain (Hooke's Law).

Since the determination of proportional limit is much more readily made than is the determination of elastic limit, it is customary to accept the proportional limit as equivalent to the elastic limit for such materials, and hence the proportional limit is frequently called the "proportional elastic limit."

In certain specifications of the Society, the term "Elastic Limit" is used to designate a value obtained by a test method which does not involve the release of stress during a test, but which does involve the determination of a limiting load at which there occurs an appreciable increase in rate of strain with respect to stress. This method may determine, for some materials, a satisfactory value of the proportional elastic limit, but the property termed "Yield Strength" determined by the "set method" as described below, is felt to be a more widely satisfactory and significant measure of the desired strength property of the material.

Yield Strength.—The stress at which a material exhibits a specified limiting permanent set.

NOTE.—It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member *begins*. Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. F. Moore, Chairman of Technical Committee I, of Committee E-1 on Mechanical Testing, University of Illinois, Urbana, Ill.

These definitions, when adopted, will be added to the Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6 – 30), see 1930 Book of A.S.T.M. Standards, Part I or Part II, pp. 932 and 1134, respectively.

The limit of usefulness of many materials, especially metals, in members subjected to approximately static loading at ordinary temperatures is therefore determined by a measurable value of plastic yielding of the material above which the material is considered to be damaged and below which the damaging effects are considered to be negligible.

The following methods are recommended for determining the yield strength of a material:

1. For material that has a "sharp-kneed" stress-strain diagram and hence exhibits at a certain stress the special characteristic of yielding without increase in stress. Two satisfactory methods are in use:

(*a*) *The "Drop of the Beam" Method.*—In this method the load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at approximately a steady rate. When the yield strength of the material is reached the increase of load stops, but the operator runs the poise a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device, there is a sudden halt of the load-indicating pointer corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield strength. This method of determining the yield strength requires only one man to conduct a test.

(*b*) *Total Strain Method Using Dividers.*—This method is frequently called the "dividers method." In this method an observer with a pair of dividers or other suitable apparatus, watches for visible elongation between two section marks on the specimen. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield strength.

Note on Yield Point.—The above two methods determine what is usually called the yield point which is commonly defined as follows:

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

It should be noted that only materials that exhibit this unique phenomenon of yielding have a yield point. The term yield point should not be used in connection with material whose stress-strain curve in the region of yield is a smooth curve of gradual curvature.

2. For material whose stress-strain diagram in the region of yield is a smooth curve of gradual curvature.

(*a*) *The Set Method.*—This method can be used, if desired, for materials having "sharp-kneed" stress-strain diagrams, but is especially adapted to materials whose stress-strain diagram in the yield range is a smooth curve of gradual curvature.

For nearly all materials, if at any point on the stress-strain diagram such as *r* in Fig. 1, the load is released the diagram for decreasing load will follow a line, *rm*, approximately parallel to the initial portion, *OA*, of the diagram for increasing load. *Om* will then give the approximate value of the permanent set after the release of the stress *OR*. The value of this set is given in percentage of original gage length. Thus to determine the yield strength by the "set method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn. Then with the stress-strain diagram (Fig. 1) lay off *Om* equal to the specified value of the set, and draw *mn* parallel to *OA* and thus locate *r*, the intersection of *mn* with the stress-strain diagram. Draw *Rr* parallel to the *X* axis and then *OR* gives the value of the yield strength.

In reporting values of yield strength obtained by this method, the specified value of "set" used should be stated in parentheses after the term yield strength. Thus:

Yield strength (set = 0.1 per cent) = 52,000 lb. per sq. in. indicates that at a stress of 52,000 lb. per sq. in. the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.[1]

In using this method, an extensometer reading to 0.0001 in. per inch of gage length would be sufficiently sensitive for most materials. It will be observed that the elastic limit and proportional limit are special values of the yield strength in which the specified limiting set is not measurable with the instruments used and hence is considered to be zero.

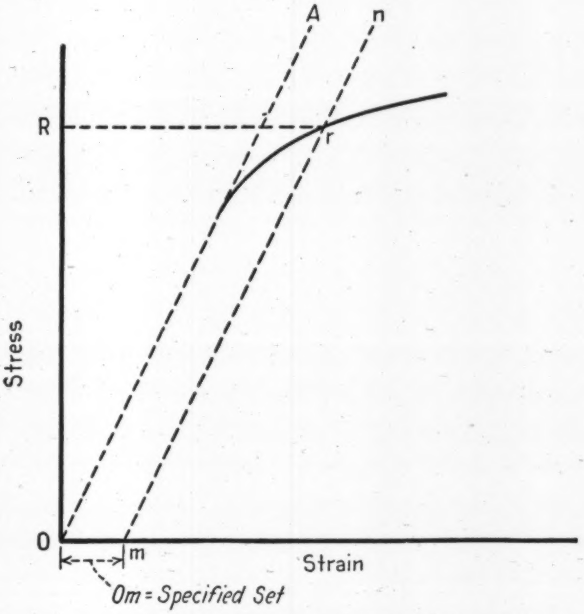

FIG. 1.—Stress-Strain Diagram.

(*b*) *Approximate Method Without Stress-Strain Diagram.*—For tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specified permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen, when this total strain is reached, is the value of the yield strength. The total strain can be obtained satisfactorily by use of an extensometer or in some cases by use of dividers particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line and if it is observed through a reading glass. But it is recommended that this approximate method be used only after agreement between producer and consumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the set method to settle any misunderstandings.

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[1] A value of 0.20 per cent of the gage length has been used rather widely for metals.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

STANDARD SPECIFICATIONS FOR LOW-CARBON-STEEL SPLICE BARS

(A.S.T.M. Designation: A 3 - 24)[1]

Section 1.—Change to read as follows by the addition of the italicized word:

1. The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

STANDARD SPECIFICATIONS FOR STEEL SCREW SPIKES

(A.S.T.M. Designation: A 66 - 21)[1]

Section 1.—Make the same change in this section as recommended in Section 1 of Specifications A 3 - 24 above.

STANDARD SPECIFICATIONS FOR LOW-CARBON-STEEL TRACK BOLTS

(A.S.T.M. Designation: A 76 - 27)[1]

Section 1 (a).—Make the same change in this section as recommended in Section 1 of Specifications A 3 - 24 above.

STANDARD SPECIFICATIONS FOR QUENCHED CARBON-STEEL TRACK BOLTS

(A.S.T.M. Designation: A 50 - 24)[1]

Section 1 (b).—Change to read as follows by the addition of the italicized words:

(*b*) The steel for the nuts shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

STANDARD SPECIFICATIONS FOR QUENCHED ALLOY-STEEL TRACK BOLTS

(A.S.T.M. Designation: A 51 - 21)[1]

Section 1 (b).—Make the same change in this section as recommended in Section 1 (*b*) of Specifications A 50 - 24 above.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

STANDARD SPECIFICATIONS FOR STEEL TIE PLATES

(A.S.T.M. DESIGNATION: A 67 - 30)[1]

Section 2.—Change to read as follows by the addition of the italicized words:

2. The steel shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

Section 3 (*a*).—Add the following requirement for copper to the requirements for chemical composition:

Copper, when copper steel is specified, per cent ....not under 0.20.

Section 4.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

4 (*a*) A carbon determination shall be made of each melt of *acid*-bessemer steel and three analyses every 24 hours representing the average of the elements carbon and phosphorus, *and also copper when copper steel is specified*, contained in the steel, one for each 8-hour turn respectively.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words:

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon and phosphorus; *also copper when copper steel is specified.*

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES

(A.S.T.M. DESIGNATION: A 65 - 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Soft Steel Track Spikes (A 65 - 32 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR BUILDINGS

(A.S.T.M. DESIGNATION: A 9 - 29)[1]

Section 1.—Change to read as follows by the addition of the italicized word and figure and the omission of the figure in brackets:

1. (*a*) Structural steel, except as noted in Paragraph (*b*), shall be made be either or both the following processes: *acid*-bessemer or open-hearth.

(*b*) Rivet steel, and steel for plates or angles over [$\frac{3}{4}$] $\frac{7}{16}$ in. in thickness which are to be punched, shall be made by the open-hearth process.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] See p. 531.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR SHIPS

(A.S.T.M. DESIGNATION: A 12 - 21)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Structural Steel for Ships (A 131 - 31 T)"[2] is intended to replace when adopted the present Standard Specifications A 12 and A 13.

STANDARD SPECIFICATIONS FOR RIVET STEEL FOR SHIPS

(A.S.T.M. DESIGNATION: A 13 - 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Structural Steel for Ships (A 131 - 31 T)"[2] is intended to replace when adopted the present Standard Specifications A 12 and A 13.

STANDARD SPECIFICATIONS FOR STRUCTURAL SILICON STEEL

(A.S.T.M. DESIGNATION: A 94 - 29)[1]

Test Specimen.—Add as Fig. 2 the accompanying Fig. 1 showing the tension test specimen.

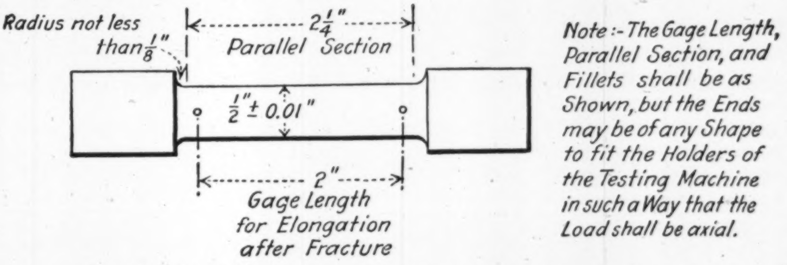
Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Section 7. (*a*).—In the table following this paragraph after the requirement for elongation in 8-in., insert a requirement for elongation in 2-in., as follows:

Elongation in 2 in., minimum, per cent.............................. $\frac{1\,600\,000}{\text{tens. str.}}$

Section 8.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) For material under 5/16 in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of 1/32 in. in thickness or diameter below 5/16 in.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 641 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 39.

Section 11 (e).—Change to read as follows by the addition of the italicized words and dimension and the omission of the dimension in brackets:

(*e*) Tension test specimens for material over [1] *1½* in. in thickness or diameter may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in. *or they may conform to the dimensions shown in Fig. 2.* (the accompanying Fig. 1).

STANDARD SPECIFICATIONS FOR BILLET-STEEL CONCRETE REINFORCEMENT BARS

(A.S.T.M. DESIGNATION: A 15 - 30)[1]

Section 3.—Change to read as follows by the addition of the italicized words:

3. (*a*) The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

(*b*) The bars shall be rolled from new billets *of properly identified heats of open-hearth or lots of acid-bessemer steel.* No rerolled material will be accepted.

Section 10.—Change this section, exclusive of the table of bend test requirements, from its present form: namely,

10. The test specimen shall stand being bent cold around a pin without cracking on the outside of the bent portion, as follows:

to read as follows:

10. The test specimen shall stand being bent cold around a pin without cracking. Bend tests shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

(*a*) Continuous and uniform application of force throughout the duration of the bending operation;

(*b*) Unrestricted movement of the specimen at points of contact with the apparatus;

(*c*) Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failures due to such methods shall not constitute a basis for rejection. The following requirements for degree of bending and sizes of pins shall be observed: (The present table of bend test requirements to be included without change.)

Section 11 (a).—Change from its present form: namely,

11 (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

to read as follows:

11. (*a*) Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.

NOTE.—The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel), or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 13.—Change this section from its present form: namely,

13. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

13. The weight of any lot of bars shall not vary more than 5 per cent over or under the theoretical or specified weight of that lot. The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars ⅜ in. and less. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

New Section.—Under a new central heading "Marking," add the following paragraph as a new Section 15, renumbering the present sections accordingly:

15. ***Marking.***—The brand of the manufacturer shall be legibly rolled on all deformed bars, and when loaded for mill shipment all bars shall be properly separated and tagged with the manufacturer's test identification number.

STANDARD SPECIFICATIONS FOR RAIL-STEEL CONCRETE REINFORCEMENT BARS

(A.S.T.M. DESIGNATION: A 16 - 14)[1]

Section 2.—Change to read as follows by the addition of the italicized words:

2. The bars shall be rolled from standard section Tee rails. *No other materials such as those known by the terms "rerolled," "rail-steel equivalent," and "rail-steel quality" shall be substituted.*

Section 6.—Change this section, exclusive of the table of bend test requirements, from its present form: namely,

6. The test specimen shall stand being bent cold around a pin without cracking on the outside of the bent portion, as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

to read as follows:

6. The test specimen shall stand being bent cold around a pin without cracking. Bend tests shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

(*a*) Continuous and uniform application of force throughout the duration of the bending operation;

(*b*) Unrestricted movement of the specimen at points of contact with the apparatus;

(*c*) Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failures due to such methods shall not constitute a basis for rejection. The following requirements for degree of bending and sizes of pins shall be observed: (The present table of bend test requirements to be included without change.)

Section 7 (*a*).—Change from its present form: namely,

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

7. (*a*) Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.

NOTE.—The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 9.—Change this section from its present form: namely,

9. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

to read as follows:

9. The weight of any lot of bars shall not vary more than 5 per cent over or under the theoretical or specified weight of that lot. The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars ⅜ in. and less. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

STANDARD SPECIFICATIONS FOR COLD-DRAWN STEEL WIRE FOR CONCRETE REINFORCEMENT

(A.S.T.M. DESIGNATION: A 82 – 27)[1]

Section 3 (*a*).—Change this section to read as follows by the addition of the italicized word:

3. (*a*) The steel shall be made by either or both of the following processes: *acid*-bessemer or open-hearth.

STANDARD SPECIFICATIONS FOR COMMERCIAL QUALITY HOT-ROLLED BAR STEELS

(A.S.T.M. DESIGNATION: A 107 – 30)[1]

Section 3.—Change this section to read as follows by the addition of the italicized word:

3. The steel shall be made by the open-hearth or *acid*-bessemer process, as specified.

STANDARD SPECIFICATIONS FOR COMMERCIAL COLD-FINISHED BAR STEELS AND COLD-FINISHED SHAFTING

(A.S.T.M. DESIGNATION: A 108 – 30)[1]

Section 3.—Change this section to read as follows by the addition of the italicized words:

3. (*a*) Bar steel shall be made by the open-hearth or *acid*-bessemer process, as specified.

(*b*) Shafting shall be made by either or both *of* the following processes: *acid*-bessemer or open-hearth.

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(A.S.T.M. DESIGNATION: A 19 – 27)[1]

Section 5.—Change from its present form: namely,

5. (*a*) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring shall be done before quenching.

(*b*) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

to read as follows:

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter of the forging, exclusive of collars and flanges.

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED ALLOY-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(A.S.T.M. DESIGNATION: A 63 - 27)[1]

Section 5.—Make the same change in this section as recommended in Section 5 of Specifications A 19 - 27 above.

STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE

(A.S.T.M. DESIGNATION: A 53 - 30)[1]

Section 2 (*a*).—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized word:

2. (*a*) The steel for welded pipe shall be soft weldable quality made by the *acid*-bessemer or by the open-hearth process.

STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL AND LAP-WELDED IRON BOILER TUBES

(A.S.T.M. DESIGNATION: A 83 - 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 32 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING

(A.S.T.M. DESIGNATION: A 89 - 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 - 32 T)"[3] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR STEEL PLATES OF STRUCTURAL QUALITY FOR FORGE WELDING

(A.S.T.M. DESIGNATION: A 78 - 30)[1]

Section 3 (*b*).—Add the following Note at the end of this section:

NOTE.—When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply, and the maximum limit for silicon shall be 0.10 per cent. In cases where fusion welding is done by special processes, or with the use of fluxes, steel with higher silicon and/or chromium contents has been successfully welded. It is suggested that in such cases the chromium and silicon desired be agreed upon by the purchaser and manufacturer.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. H. P. Bigler, Secretary of Committee A-1 on Steel, Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.

[2] See p. 549.

[3] See p. 543.

STANDARD SPECIFICATIONS FOR STAYBOLT, ENGINE-BOLT AND EXTRA-REFINED WROUGHT-IRON BARS

(A.S.T.M. Designation: A 84 – 30)[1]

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Standard Specifications for Staybolt, Engine-Bolt and [Extra-Refined] ***Other High-Grade*** Wrought-Iron Bars.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

1. These specifications cover three grades of bar iron:
Grade A.—Staybolt iron, ***round bars only.***
Grade B.—Engine-bolt iron, ***round and hexagon bars only.***
Grade [C] B_1.—[Extra-refined wrought-iron] ***All rectangular*** bars.

Section 2.—In the second paragraph change the words "Grades B and C" to read "Grades B and B_1."

Section 6 (a).—Change the physical properties of the third grade of iron in the table following Paragraph (*a*) to read as follows by the addition of the italicized letter and figures and the omission of those in brackets:

		Grade [C] B_1
Tensile strength, lb. per sq. in.	1½ sq. in. or under in sectional area	48 000 – [54 000] *53 000*
	Over 1½ sq. in. in sectional area	[48 000 – 54 000] *47 000 – 53 000*
Yield point, min., lb. per sq. in.	1½ sq. in. or under in sectional area	0.6 tens. str.
	Over 1½ sq. in. to 4 sq. in., incl., in sectional area	0.55 tens. str.
	Over 4 sq. in. in sectional area	0.50 tens. str.
Elongation in 8 in., min., per cent		25
Reduction of area, min., per cent		[37] *35*

Section 7.—Omit Paragraph (*c*) which reads as follows:

(*c*) *Grade A.*—For flats of all sizes, the minimum reduction of area shall be 40 per cent.

Reletter Paragraph (*d*) as Paragraph (*c*) and change "Grade C" to read "Grade B_1."

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-2 on Wrought Iron, Reading Iron Co., 401 N. Broad St., Philadelphia, Pa.

Section 8 (a).—In the second paragraph change "Grade B" to read "Grades B and B_1" and omit the third paragraph which reads as follows:

> *Grade C.*—Cold-bend tests will be made only on bars having a nominal section area of 4 sq. in. or under, in which case the test specimen shall stand being bent cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to the thickness of the specimen.

Section 8 (b).—Change "Grades B and C" to read "Grades B and B_1."

Section 9.—In the third paragraph of this section change "Grades B and C" to read "Grades B and B_1."

Section 10 (a).—Change from its present form: namely,

> 10. (*a*) Tension and bend test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimens shall be machined from the material as rolled; the axis of the specimen shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars, and shall be parallel to the axis of the bar.

to read as follows:

> 10. (*a*) Tension test specimens for all grades and bend test specimens for Grades A and B shall be of the full section of the material as rolled, if possible; otherwise the specimen shall be machined from the material as rolled. Bend test specimens for Grade B_1 may be reduced by machining to an approximate square, the side of which is equal to the thickness of the original bar. The axes of all specimens shall be parallel to the axis of the bar and shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars.

Section 12.—In the third paragraph change "Grade C" to read "Grade B_1."

Section 16 (c).—In the second paragraph change "Grades B and C" to read "Grades B and B_1."

STANDARD SPECIFICATIONS FOR CHILLED CAST-IRON WHEELS

(A.S.T.M. DESIGNATION: A 46 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Chilled-Tread Cast-Iron Wheels (A 46 – 30 T)"[2] is intended to replace when adopted the present standard specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 976 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 172.

STANDARD SPECIFICATIONS FOR GRAY-IRON CASTINGS

(A.S.T.M. DESIGNATION: A 48 – 29)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Gray-Iron Castings (A 48 – 32 T)"[2] is intended to replace when adopted the present Standard Specifications A 48 – 29 and A 88 – 31.

STANDARD SPECIFICATIONS FOR HIGH-TEST GRAY-IRON CASTINGS

(A.S.T.M. DESIGNATION: A 88 – 31)[3]

A revision in the form of separate tentative specifications entitled "Specifications for Gray-Iron Castings (A 48 – 32 T)"[2] is intended to replace when adopted the present Standard Specifications A 48 – 29 and A 88 – 31.

STANDARD SPECIFICATIONS FOR MALLEABLE CASTINGS

(A.S.T.M. DESIGNATION: A 47 – 30)[4]

A revision in the form of separate tentative specifications entitled "Specifications for Malleable Iron Castings (A 47 – 32 T)"[5] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) IRON OR STEEL TELEPHONE AND TELEGRAPH LINE WIRE

(A.S.T.M. DESIGNATION: A 111 – 30)[6]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (A 111 – 32 T)"[7] is intended to replace when adopted the present standard specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

[2] See p. 625.

[3] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

[4] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed tc Mr. Enrique Touceda, Secretary of Committee A-7 on Malleable Iron Castings, 943 Broadway, Albany, N. Y.

[5] See p. 633.

[6] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

[7] See p. 589.

STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) IRON OR STEEL TIE WIRES

(A.S.T.M. DESIGNATION: A 112 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (A 112 – 32 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) IRON OR STEEL FARM-FIELD AND RAILROAD RIGHT-OF-WAY WIRE FENCING

(A.S.T.M. DESIGNATION: A 116 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 32 T)"[3] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR ZINC-COATED IRON OR STEEL CHAIN-LINK FENCE FABRIC GALVANIZED AFTER WEAVING

(A.S.T.M. DESIGNATION: A 117 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated Iron or Steel Chain-Link Fence Fabric Galvanized After Weaving (A 117 – 32 T)"[4] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) IRON OR STEEL BARB WIRE

(A.S.T.M. DESIGNATION: A 121 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated (Galvanized) Iron or Steel Barb Wire (A 121 – 32 T)"[5] is intended to replace when adopted the present standard specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 595.

[3] See p. 599.

[4] See p. 603.

[5] See p. 606.

STANDARD SPECIFICATIONS FOR ZINC-COATED (GALVANIZED) IRON OR STEEL WIRE STRAND

(A.S.T.M. DESIGNATION: A 122 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A 122 – 32 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD METHODS OF TEST FOR MAGNETIC PROPERTIES OF IRON AND STEEL

(A.S.T.M. DESIGNATION: A 34 – 28)[3]

A revision in the form of separate tentative methods entitled "Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 32 T)"[4] is intended to replace when adopted the present standard methods.

STANDARD METHODS OF CHEMICAL ANALYSIS OF FERRO-ALLOYS

(A.S.T.M. DESIGNATION: A 104 – 27)[5]

A revision in the form of separate tentative methods entitled "Methods of Chemical Analysis of Ferro-Tungsten and Ferro-Molybdenum (A 104 – 32 T)"[6] is intended, when adopted as standard, to be incorporated in the present standard methods.

STANDARD DEFINITIONS OF TERMS RELATING TO HEAT TREATMENT OPERATIONS (ESPECIALLY AS RELATED TO FERROUS ALLOYS)

(A.S.T.M. DESIGNATION: A 119 – 30)[7]

Heat Treatment.—Change the definition of "heat treatment" to read as follows by the addition of the italicized words and the omission of those in brackets:

Heat Treatment.—An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state *for the purpose of obtaining certain desirable conditions or properties.*

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 609.

[3] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

[4] See p. 650.

[5] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall St., New York City.

[6] See p. 641.

[7] 1930 Book of A.S.T.M. Standards, Part I. Criticims of this revision are solicited and should be directed to Mr. J. H. Hall, Secretary of Committee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

Note.—[This is for the purpose of obtaining certain desirable conditions or properties.] Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of this definition.

Annealing.—Change the definition of "annealing" to read as follows by the addition of the italicized words and the omission of Note 1, shown in brackets, leaving the present Note 2 as the only note under this section:

Annealing.—A heating and cooling operation of a material in the solid state *and usually implies a relatively slow cooling.*

[NOTE 1.—Annealing usually implies a relatively slow cooling.]

Normalizing.—Change the definition of "normalizing" to read as follows by the addition of the italicized phrase and sentences and the omission of the sentence in brackets.

Normalizing.—Heating iron-base alloys *to approximately 100° F.* above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

NOTE.—[In the case of hyper-eutectoid steel, it is often desirable to heat above the Ac_{cm} line, as shown in Fig. 2.] *Normalizing is rarely practiced with hyper-eutectoid steels because of the coarsening of the grain and the tendency to crystallize cementite at grain boundaries or in needles. However, it may sometimes be necessary to normalize these steels by heating them above the* Ac_{cm} *line of the iron carbon diagram as shown in Fig. 2.*

Tempering (also termed Drawing).—Change the definition of "tempering" to read as follows by the addition of the italicized words:

Tempering (also termed Drawing).—Reheating *iron-base alloys* after hardening to some temperature below the critical temperature range followed by any desired rate of cooling.

New Definition.—Add a new definition of the term "nitriding" reading as follows:

Nitriding.—Adding nitrogen to iron-base alloys by heating the metal in contact with ammonia gas or other suitable nitrogenous material.

NOTE.—Nitriding is conducted at a temperature below the iron-carbon critical temperature range and produces surface hardening of the metal without quenching.

STANDARD DEFINITIONS OF TERMS RELATING TO WROUGHT IRON SPECIFICATIONS

(A.S.T.M. DESIGNATION: A 81 – 30)[1]

Double Refined Iron.—Change from its present form: namely,

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-2 on Wrought Iron, Reading Iron Co., 401 N. Broad St., Philadelphia, Pa.

Double Refined Iron.—Iron rolled from a slab pile or box pile of refined iron bars, all bars running the full length of the pile.

to read as follows:

Double-Refined Iron.—Iron to be classed as double refined, shall be all new wrought iron,[a] which shall be first rolled into muck bars. These bars shall then be twice piled and rerolled. All iron shall be free from steel and from foreign scrap. The manufacturer may use his own mill products of at least equal quality, but only in the first piling. In the final piling all bars shall be of the full length of the pile.

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[a] Wrought Iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

B. NON-FERROUS METALS

STANDARD SPECIFICATIONS FOR COPPER PLATES FOR LOCOMOTIVE FIREBOXES

(A.S.T.M. DESIGNATION: B 11 – 18)[1]

Section 3 (b).—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

(*b*) Non-arsenical Copper.—Non-arsenical copper shall have a purity of at least [99.880] *99.90* per cent, as determined by electrolytic assay, silver being counted as copper. The total of impurities other than silver shall not exceed [0.120] *0.10* per cent.

STANDARD SPECIFICATIONS FOR COPPER BARS FOR LOCOMOTIVE STAYBOLTS

(A.S.T.M. DESIGNATION: B 12 – 21)[1]

Section 3 (b).—Make the same change in this paragraph as recommended in Section 3 (*b*) of Specifications B 11 – 18 above.

STANDARD SPECIFICATIONS FOR SEAMLESS COPPER BOILER TUBES

(A.S.T.M. DESIGNATION: B 13 – 18)[1]

Section 3 (b).—Make the same change in this paragraph as recommended in Section 3 (*b*) of Specifications B 11 – 18 above.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

STANDARD SPECIFICATIONS FOR COPPER PIPE, STANDARD SIZES

(A.S.T.M. Designation: B 42 - 24)[1]

Section 3.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

3. The copper shall have a purity of at least [99.880] *99.90* per cent as determined by electrolytic assay, silver being counted as copper.

Section 12.—It is recommended that the first sentence in Paragraph (*a*) of this section, which reads as follows, be omitted as it conflicts with the requirements of Paragraph (*b*):

No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted.

STANDARD SPECIFICATIONS FOR BRASS PIPE, STANDARD SIZES

(A.S.T.M. Designation: B 43 - 24)[1]

Section 3 (b).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) All pipe shall be annealed sufficiently to prevent cracking. Semi-annealed pipe, which is suitable for ordinary uses, shall be furnished [unless otherwise specified] *except that red brass pipe may be furnished hard drawn.*

Section 4.—Change the table showing the chemical composition from its present form: namely,

	Hot Pierced Process	Cold Process
Copper, per cent................	59.00 - 63.00	65.00 - 68.00
Lead, maximum, per cent........	0.50	0.80
Iron, maximum, per cent........	0.07	0.07
Zinc.........................	remainder	remainder

to read as follows:

	Muntz Metal	High Brass	Admiralty Metal	Red Brass
Copper, per cent	59.00 to 63.00	65.00 to 68.00	70.00 to 73.00	84.00 to 87.00
Lead, maximum, per cent......	0.50	0.80	0.07	0.07
Iron, maximum, per cent......	0.07	0.07	0.07	0.07
Tin, per cent...	0.15 maximum	0.15 maximum	0.90 to 1.20	0.15 maximum
Zinc, per cent..	remainder	remainder	remainder	remainder

Explanatory Note.—Add a note covering rejection for high tin content, the note to read as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

NOTE.—The ideal composition for admiralty metal is 70 per cent of copper, 29 per cent of zinc, and 1 per cent of tin, and better tubes will be obtained by adhering as closely as possible to this composition, particularly as to tin. It does not, therefore, seem wise to make 1 per cent of tin the minimum but rather, in order to obtain as nearly 1 per cent as possible, to allow some variation under 1 per cent and make the minimum limit for tin 0.90 per cent. Owing to the fact that a minimum of 1 per cent tin has heretofore existed, cases will occur, until the present specifications become universal, where the tin may exceed the 1.20 per cent maximum. It is not considered that this would be harmful or should be made a cause for rejection.

Table I.—The present columns for nominal weight per foot of pipe now apply to muntz metal, high brass and admiralty metal. It is recommended that the accompanying Table I showing nominal weights per foot of red brass pipe, be added to Table I of the specifications.

TABLE I.—STANDARD WEIGHTS FOR RED BRASS PIPE.

	RED BRASS	
SIZE OF PIPE, IN.	STANDARD PIPE NOMINAL WEIGHT, LB. PER FT. OF LENGTH	EXTRA-STRONG PIPE NOMINAL WEIGHT, LB. PER FT. OF LENGTH
⅛	0.253	0.363
¼	0.450	0.611
⅜	0.630	0.829
½	0.938	1.23
¾	1.27	1.67
1	1.79	2.46
1¼	2.63	3.39
1½	3.13	4.10
2	4.14	5.67
2½	6.00	8.66
3	8.56	11.57
3½	11.17	14.07
4	12.66	16.89
4½	14.15	20.66
5	15.85	23.18
6	18.99	32.21
7	24.63	42.43
8	30.95	48.39
9	38.03	54.34
10	45.20	61.05

Section 6.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) Specimens of hard-drawn red brass pipe shall be annealed previous to the hammering test.

Section 7.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) Specimens of hard-drawn red brass pipe shall be annealed previous to the flattening test.

Section 14.—It is recommended that the first sentence in Paragraph (*a*) of this section, which reads as follows, be omitted as it conflicts with the requirements of Paragraph (*b*):

No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted.

STANDARD SPECIFICATIONS FOR SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 44 - 29)[1]

Section 14.—Change from its present form: namely,

14. The length shall not be less but may be $\frac{1}{16}$ in. more than that ordered when measured at a temperature of 20° C. (68° F.).

to read as follows:

14. The length shall not be less than that ordered when measured at a temperature of 20° C. (68° F.), but may be more than that ordered by the amounts in the following table:

ORDERED LENGTH, FT.	PERMISSIBLE TOLERANCES, IN.
Up to 15, inclusive	$+\frac{1}{16}$
Over 15 to 20, inclusive	$+\frac{3}{32}$
Over 20	$+\frac{1}{8}$

STANDARD SPECIFICATIONS FOR SEAMLESS 70-30 BRASS CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 55 - 25)[1]

Section 14.—Make the same change in this section as recommended in Section 14 of Specifications B 44 - 29 above.

STANDARD SPECIFICATIONS FOR SEAMLESS MUNTZ METAL CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 56 - 25)[1]

Section 14.—Make the same change in this section as recommended in Section 14 of Specifications B 44 - 29 above.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

STANDARD SPECIFICATIONS FOR SHEET HIGH BRASS
(A.S.T.M. DESIGNATION: B 36 – 27)[1]

Section 1.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) Sheet high brass shall be furnished in two grades, described as Grade Nos. 1 and 2.

Section 3.—Change the table showing the chemical composition from its present form: namely,

Copper	64.5 to 67.5 per cent
Lead	not over 0.30 per cent
Iron	not over 0.05 per cent
Zinc	remainder
Other impurities	not over 0.10 per cent

to read as follows:

	GRADE NO. 1	GRADE NO. 2
Copper	66 to 69 per cent	64.5 to 67.5 per cent
Lead	not over 0.07 per cent	not over 0.35 per cent
Iron	not over 0.04 per cent	not over 0.06 per cent
Zinc	remainder	remainder

Section 5.—Omit Paragraph (*a*), reading as follows, and renumber the present Paragraph (*b*) as Section 5:

5. (*a*) Analyses of separate pieces may be made by the purchaser. The copper, lead, and iron determined shall be within the following limits:

Copper	64.00 to 68.00 per cent
Lead	not over 0.35 per cent
Iron	not over 0.07 per cent

Section 6.—Change this section to read as follows by the addition of the italicized words and figures:

6. The temper of *rolled* sheet brass shall be designated as follows:

	REDUCTION, B. & S. GAGE NOS.
Quarter Hard	1
Half Hard	2
Three-quarter Hard	*3*
Hard	4
Extra Hard	6
Spring	8
Extra Spring	*10*

Section 7.—Change this section to read as follows by the addition of the italicized words and letters and the omission of the words in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

7. *The tempers of* annealed sheet brass shall be designated as follows:

[Light] *A* Anneal
[Drawing] *B* Anneal
[Soft Drawing] *C* Anneal
D Anneal
E Anneal

Sections 8 to 11.—Change the Sections on (*A*) *Hard Brass* and (*B*) *Soft Brass* under Physical Properties and Tests to read as follows:

PHYSICAL PROPERTIES AND TESTS

(*A*) *Rolled Tempers*

8. The tension test shall be standard for all rolled tempers and acceptance or rejection shall depend only on tensile strength values given in Section 9. However, for convenience in testing, Rockwell hardness test values are also given for some thicknesses. These should be considered as approximate and informatory only.

9. The average tensile strength of two samples of rolled sheet shall be within the limits given in the following table. Rockwell hardness values corresponding to these strengths in certain thicknesses are given for informatory purposes only.

	TENSILE STRENGTH, LB. PER SQ. IN., ALL THICKNESSES		THICKNESSES TO WHICH ROCKWELL VALUES APPLY, IN.	ROCKWELL HARDNESS (B SCALE, $\frac{1}{16}$-IN. BALL, 100-KG. LOAD) TESTING ONE THICKNESS ONLY	
TEMPER	MINIMUM	MAXIMUM		MINIMUM	MAXIMUM
Quarter Hard.......	46 000	56 000	Over 0.040	30	60
			0.020 to 0.040	30	56
Half Hard..........	53 500	63 500	Over 0.040	50	73
			0.020 to 0.040	49	71
Three-quarter Hard..	61 000	71 000	Over 0.040	70	80
			0.020 to 0.040	67	77
Hard..............	68 000	78 000	Over 0.040	78	85
			0.020 to 0.040	75	83
Extra Hard.........	79 000	88 500	Over 0.040	85	89
			0.020 to 0.040	83	87
Spring.............	86 000	95 000	Over 0.040	88	92
			0.020 to 0.040	85	89
Extra Spring........	89 500	98 500	Over 0.040	89	93
			0.020 to 0.040	86	90

(*B*) *Annealed Tempers*

10. Grain size shall be the standard test for all thicknesses in annealed tempers and acceptance or rejection shall depend on grain sizes given in Section 11.[1] However, for convenience in testing, Rockwell hardness values are given for sheet over 0.020-in. in thickness. These should be considered as approximate and informatory only.

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[1] Standard rules governing the preparation of micrographs and photographic grain size standards for brass are given in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (A.S.T.M. Designation: E 2), see 1930 Book of A.S.T.M. Standards, Part I, p. 898.

11. The average grain size of two samples of annealed sheet shall be within the limits given in the following table. For comparative and informatory purposes, corresponding Rockwell hardness values in thicknesses 0.020 in. and over are given:

			ROCKWELL HARDNESS (B SCALE, $\frac{1}{16}$-IN. BALL, 60-KG. LOAD) TESTING ONE THICKNESS ONLY					
	AVERAGE GRAIN SIZE, MM.		THICKNESSES 0.020 TO 0.026 IN.		THICKNESSES OVER 0.026 TO 0.040 IN.		THICKNESSES OVER 0.040 IN.	
NOMINAL TEMPER	MINIMUM	MAXIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
A	0.100	.....	58	..	57	..	56	..
B	0.050	0.110	68	54	67	52	65	52
C	0.035	0.070	72	59	71	57	70	57
D	0.025	0.050	75	62	74	61	75	61
E	.....	0.035	..	67	..	65	..	65

NOTE.—The data on tensile strength, grain size, and Rockwell hardness values, given in Sections 9 and 11, are based on results from a large amount of careful testing by several prominent laboratories, and are believed to be accurate. However, due to the importance of the changes made, the committee wishes to expressly point out the possible necessity for some slight revision after further actual service experience.

STANDARD METHODS OF CHEMICAL ANALYSIS OF MANGANESE BRONZE

(A.S.T.M. DESIGNATION: B 27 – 19)[1]

Under the Determination of Manganese by the Persulfate Method, change the description under Method from its present form: namely,

In a 250-cc. Erlenmeyer flask dissolve 1 g. of bronze in 24 cc. of the "solution for dissolving." Allow to stand on a steam bath or hot plate until entirely dissolved, and until the oxides of nitrogen are expelled. Add 15 cc. of $AgNO_3$ solution and 20 cc. of ammonium persulfate and leave on the steam bath until the solution has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C. in running water, and add 50 cc. of cold water. Titrate with standard sodium-arsenite solution to the disappearance of the pink color.

to read as follows:

Adjust the size of sample to the expected percentage so that the portion taken does not contain more than 0.002 g. manganese. Place it in a 250-cc. Erlenmeyer flask with 24 cc. of the "solution for dissolving" and heat until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, *Metal Progress*, 7016 Euclid Ave., Cleveland, Ohio.

100 cc. with boiling-hot water, add 20 cc. of $AgNO_3$ solution and 30 cc. of the persulfate solution, then remove to a moderately warm place to stand for a few minutes for complete development of the permanganic acid. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

C. CEMENT, LIME, GYPSUM, CONCRETE AND CLAY PRODUCTS

STANDARD SPECIFICATIONS FOR HYDRATED LIME FOR STRUCTURAL PURPOSES

(A.S.T.M. DESIGNATION: C 6 - 31)[1]

Section 12.—Change the second and fifth paragraphs from their present form: namely,

> The lime shall be made into a stiff putty with water and permitted to soak over night. It shall be molded in a ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

to read respectively as follows:

> The lime shall be made into a stiff putty with water, stirred vigorously with a trowel or spatula for three minutes and permitted to soak over night. It shall be stirred vigorously with a trowel or spatula for three minutes, molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, stirred vigorously with a trowel or spatula for three minutes, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

Section 13.—Change the first paragraph to read as follows by the addition of the italicized words:

> 13. Plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows: Three hundred grams of the sample shall be mixed with enough water to form a thick putty *and stirred vigorously for 3 minutes with a trowel or spatula.* After aging in a vessel covered with a damp cloth for not less than 16 nor more than 24 hours, this putty shall be *stirred vigorously for 3 minutes with a trowel or spatula and* adjusted to standard consistency, as defined in Section 12, with a permissible variation of ±5 mm.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. V. Brumbaugh, Secretary of Committee C-7 on Lime, 927 Fifteenth St., N. W., Washington, D. C.

STANDARD SPECIFICATIONS FOR CLAY SEWER PIPE

(A.S.T.M. DESIGNATION: C 13 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Clay Sewer Pipe (C 13 – 32 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE

(A.S.T.M. DESIGNATION: C 14 – 24)[3]

Section 1.—Add the following footnote:

Caution.—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction.

STANDARD SPECIFICATIONS FOR GYPSUM WALL BOARD

(A.S.T.M. DESIGNATION: C 36 – 25)[4]

A revision in the form of separate tentative specifications entitled "Specifications for Gypsum Wall Board (C 36 – 31 T)"[5] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR GYPSUM PLASTER BOARD

(A.S.T.M. DESIGNATION: C 37 – 30)[4]

A revision in the form of separate tentative specifications entitled "Specifications for Gypsum Lath (C 37 – 31 T)"[6] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR GYPSUM PARTITION TILE OR BLOCK

(A.S.T.M. DESIGNATION: C 52 – 27)[4]

Section 13.—Change the first sentence of Paragraph (*b*) from its present form: namely,

> The test specimens shall be dried to constant weight at a temperature not exceeding 110° F. (43° C.), until two successive weighings of the same specimen do not show a variation in excess of 0.5 per cent.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. E. S. Rankin, Secretary of Committee C-4 on Clay Pipe, Bureau of Sewers, City Hall, Newark, N. J.

[2] See p. 724.

[3] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. A. E. Phillips, Temporary Chairman of Committee C-13 on Concrete Pipe, 2400 Wyoming Ave., N. W., Washington, D. C.

[4] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 740 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 345.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 743 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 348.

to read as follows:

The test specimens shall be dried at a temperature of not less than 21.1° C. (70° F.) nor more than 37.8° C. (100° F.) in an atmosphere of not more than 50 per cent relative humidity. The specimen shall be weighed at 1-day intervals until constant weight is attained.

Change Paragraph (*c*) from its present form: namely,

(*c*) The tile or block shall be tested in the position in which they are designed to be used and shall be bedded on and capped with a felt gasket not less than ⅛ in. nor more than ¼ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test samples may be suitably bedded and capped with neat gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When neat gypsum mortar is used for bedding and capping, the test may be conducted after the mortar has set, but not sooner than twenty-four hours after the sample has been capped.

to read as follows:

(*c*) The tile or block shall be tested in the position in which it is designed to be used, and shall be bedded on and capped with a felt pad not less than ⅛ in. nor more than ¼ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test samples may be suitably capped with calcined gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When calcined gypsum is used for capping, the test may be conducted after the capping has set, and the specimen tile dried to constant weight in accordance with Paragraph (*b*).

Section 14.—This section deals with the method of testing to determine the modulus of rupture of gypsum tile or block but there are no minimum modulus of rupture requirements given in the specifications. It is felt that since a gypsum partition tile is a non-loadbearing unit and is erected on edge that the compressive strength requirement is adequate. The committee therefore recommends that Section 14 be omitted from the specifications, renumbering the present Section 15 as Section 14.

STANDARD METHODS OF TESTING GYPSUM AND GYPSUM PRODUCTS

(A.S.T.M. DESIGNATION: C 26 – 30)[1]

A revision in the form of separate tentative methods entitled "Methods of Testing Gypsum and Gypsum Products (C 26 – 32 T)"[2] is intended to replace when adopted the present standard methods.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

[2] See p. 700.

STANDARD METHOD OF TEST FOR POROSITY AND PERMANENT VOLUME CHANGES IN REFRACTORY MATERIALS

(A.S.T.M. DESIGNATION: C 20 - 20)[1]

Section 5.—Change Paragraphs (*c*), (*d*), (*e*), (*f*), (*g*), and (*h*) from their present form: namely,

(*c*) The test specimens shall be placed in kerosine of known density (δ) under a vacuum of 24 in. for 4 hours at 25° C. and cooled to room temperature while yet immersed.

(*d*) When cool, each test specimen shall be weighed suspended in kerosine at 25° C. to determine its *Suspended Weight* (S), in grams.

(*e*) The *Saturated Weight* (W), in grams, of each test specimen shall be obtained immediately after obtaining the suspended weight, by drying lightly with a kerosine-moistened towel to remove the excess kerosine and then weighing in air.

(*f*) The *Exterior Volume* (V), in cubic centimeters, of each test specimen is obtained by subtracting the suspended weight (S) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V = \frac{W - S}{\delta} \qquad (1)$$

(*g*) The *Actual Volume of Open Pores* (V_1) in cubic centimeters, is obtained by subtracting the dry weight (D) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V_1 = \frac{W - D}{\delta} \qquad (2)$$

(*h*) The *Apparent Specific Gravity* (T_1) of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights, and multiplying by the density of the kerosine. Thus:

$$T_1 = \frac{D}{D - S}\delta \qquad (3)$$

to read as follows:

(*c*) The test specimens shall be placed in distilled water and boiled for 2 hours and then allowed to cool to room temperature while still immersed in water. During boiling, the test specimens shall not be in contact with the heated bottom of the container.

(*d*) *Weight Suspended in Water.*—Each test specimen shall be weighed while suspended in water to the nearest 0.10 g. to determine its suspended weight, S, in grams.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

(*e*) *Saturated Weight.*—The saturated weight, W, in grams of each test specimen shall be obtained immediately after obtaining the suspended weight, S, by blotting lightly with a moistened towel to remove the excess water and then **weighing in air to the nearest 0.10 g.**

(*f*) *Exterior Volume.*—The exterior volume, V, in cubic centimeters of each test specimen is obtained by subtracting the suspended weight, S, from the saturated weight, W.

(*g*) *Actual Volume of Open Pores.*—The actual volume of open pores, V_1, in cubic centimeters is obtained by subtracting the dry weight, D, from the saturated weight, W.

(*h*) *Apparent Specific Gravity.*—The apparent specific gravity, T_1, of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights as follows:

$$T_1 = \frac{D}{D - S}$$

In the formulas which appear in Paragraphs (*j*) and (*k*) omit the function "δ" for the density of kerosine.

New Paragraph.—Add the following new Paragraph (*l*) to Section 5:

(*l*) *Water Absorption.*—The water absorption, A, in per cent is obtained by dividing the weight of the water absorbed in grams, by the weight of the dry test specimens in grams and multiplying by 100 as follows:

$$A = \frac{W - D}{D} \times 100$$

STANDARD METHOD OF TEST FOR SOFTENING POINT OF FIRE-CLAY BRICK

(A.S.T.M. DESIGNATION: C 24 – 31)[1]

Title.—Change the title of this method to read as follows, by the addition of the italicized words and the omission of those in brackets:

Standard Method of Test for [Softening Point] *Determining the Pyrometric Cone Equivalent* of Fire-Clay *and Fire* Brick.

Section 1.—Change the scope section from its present form: namely,

1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

to read as follows:

1. This method is intended for determining the pyrometric cone equivalent of fire clay, fire brick, silica cement and ground fire clay by comparison of test cones with standard Orton pyrometric cones under the conditions herein prescribed.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

Section 2.—Change the description of the preparation of sample from its present form: namely,

2. A 1-kg. (2-lb) sample shall be taken by chipping off approximately equal portions from the corners of the brick. These fragments shall be reduced in size by means of rolls or a jaw crusher adjusted to pass a lump 6 mm. (¼ in.) in diameter. They shall be mixed thoroughly, and the amount of material reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall be ground in a porcelain or agate mortar to pass a No. 60 sieve of the U. S Standard Sieve Series. In order to avoid excessive reduction of the fines, they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

to read as follows:

2. (*a*) *Lump Clay or Brick.*—The entire sample of lump clay or brick, in case the amount is small shall be reduced in size by means of rolls or a jaw crusher to a maximum size of ¼ in In case the amount is large, a representative sample obtained by approved methods shall be so treated. The sample shall then be mixed thoroughly and the amount reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall then be ground in an agate, porcelain, or hard steel mortar and the amount reduced again by quartering. The final size of the sample shall be 50 g. and the fineness such that it will pass a No. 65 sieve, the diameter of wire being 0.183 mm. (0.0072 in.) and the screen openings being 0.208 mm. (0.0082 in.). In order to avoid excessive reduction of fines they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

(*b*) In the case of ground fire clay and silica cements, the sample obtained by approved methods shall be tested as received without grinding or other treatment.

The addition of the following Note after Section 2 is recommended since it is felt necessary to avoid the use of the P. C. E. test on refractory cements containing added fluxes, which is at present a subject of study.

NOTE.—For the purpose of this test, silica cement is understood to be the usual mixture of ground ganister and fire clay with no added fluxes. By ground fire clay is understood the usual mixture of ground raw fire clay, calcined clay, or burnt brick with no added fluxes. Neither includes the materials sold under the name of high-temperature cements.

Section 3 (a).—Change the description of the test cones from its present form: namely,

3. (*a*) The sample thus prepared shall be thoroughly mixed and, after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. (3/16 in.) on the sides at the base and 25 mm. (1 in.) high.

to read as follows:

3. (*a*) The dried sample shall be thoroughly mixed and after the addition of sufficient dextrine, glue, gum tragacanth or other alkali-free organic binder and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons 8 mm. ($\frac{5}{16}$ in.) on the sides at the base and 25 mm. (1 in.) in height.

Section 5.—Add to the table of heating rates following Paragraph (*a*) the following requirements for cones Nos. 36, 37 and 38, not heretofore provided for:

Time interval to cone 36	10 minutes
" " " " 37	4 "
" " " " 38	6 "

Appendix.—Add the following cone temperature table as Appendix to these methods:

The temperature corresponding with the end points of those standard Orton pyrometric cones, which are used in connection with refractories, are as follows:

	END POINT			END POINT	
CONE	DEG. CENT.	DEG. FAHR.	CONE	DEG. CENT.	DEG. FAHR.
No. 15	1435	2615	No. 29	1640	2984
No. 16	1465	2669	No. 30	1650	3002
No. 17	1475	2687	No. 31	1680	3056
No. 18	1490	2714	No. 32	1700	3092
No. 19	1520	2768	No. 33	1745	3173
No. 20	1530	2786	No. 34	1760	3200
No. 23	1580	2876	No. 35	1785	3245
No. 26	1595	2903	No. 36	1810	3290
No. 27	1605	2921	No. 37	1820	3308
No. 28	1615	2939	No. 38	1835	3335

NOTE.—These temperatures, which were determined by Fairchild and Peters[a] for a heating rate of 150° C. per hour for cones Nos. 15 to 20, and of 100° C. per hour for cones Nos. 23 to 38, other conditions being the same as specified, apply satisfactorily for all the conditions of this test method, but do not apply to conditions of the commercial firing and use of refractory materials.

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[a] Fairchild and Peters, "Characteristics of Pyrometric Cones," *Journal*, Am. Ceramic Soc., Vol. 9, No. 11, p. 700, November, 1926.

STANDARD METHOD OF MAKING AND STORING COMPRESSION TEST SPECIMENS OF CONCRETE IN THE FIELD

(A.S.T.M. DESIGNATION: C 31 – 31)[1]

Section 5 (*b*).—Change this paragraph from its present form: namely,

(*b*) The test specimens shall be molded by placing the concrete in the mold in layers 3 to 4 in. in thickness. Each layer shall be puddled with 25 strokes with a $\frac{5}{8}$-in. rod 24 in. in length bullet-pointed at the lower end. After puddling the top layer, the surface concrete shall be struck off with a trowel and covered with the top cover plate which may later be used in capping the test specimen.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

to read as follows:

(*b*) The test specimens shall be molded by placing the fresh concrete in the mold in three layers, each approximately one-third the volume of the mold. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mold as the concrete slides from it in order to insure a symmetrical distribution of concrete within the mold. Each layer shall be rodded with 25 strokes of a ⅝-in. rod 24 in. in length, bullet-pointed at the lower end. The strokes shall be distributed in a uniform manner over the cross-section of the mold and shall penetrate into the underlying layer. The bottom layer shall be rodded throughout its depth. After the top layer has been rodded the surface of the concrete shall be struck off with a trowel and covered with a glass plate at least ¼ in. in thickness or with a machined metal plate, which may be used later in capping the test specimens.

STANDARD METHODS OF MAKING COMPRESSION TESTS OF CONCRETE

(A.S.T.M. DESIGNATION: C 39 – 27)[1]

Section 13.—Change this section from its present form: namely,

13. Concrete test specimens shall be molded by placing the fresh concrete in the mold in layers 3 to 4 in. in thickness. Each layer shall be puddled with 25 strokes with a ⅝-in. rod 24 in. in length, bullet-pointed at the lower end. After the top layer has been puddled, the surplus concrete shall be struck off with a trowel, and the mold covered with a piece of plate glass at least ¼ in. in thickness or a machined metal plate which will be used later in capping the test specimen.

to read the same as proposed for the revision of Section 5(*b*) in Method C 31 – 31 given above.

STANDARD METHOD OF TEST FOR ORGANIC IMPURITIES IN SANDS FOR CONCRETE

(A.S.T.M. DESIGNATION: C 40 – 27)[1]

Sections 3 (b) and 4.—Add a footnote reference after the term "sodium hydroxide" to refer to the following footnote:

Where chemically pure sodium hydroxide is not available, commercial soda lye may be used.

New Section.—Add a new Section 6 to read as follows:

6. In lieu of the method described in Section 5 (*a*), the color of the clear liquid above the sand may be compared with the colors given in Fig. 1 (Plate I).[2]

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

[2] This figure is not included. The color chart referred to appears in *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part I, p. 322 (1919).

STANDARD METHOD OF TEST FOR SIEVE ANALYSIS OF AGGREGATES FOR CONCRETE

(A.S.T.M. DESIGNATION: C 41 – 24)[1]

In order to clarify the purpose of this standard method, the addition of the following paragraph as a footnote is recommended:

> This method is intended primarily for use in connection with the sieve analysis of either coarse aggregates or mixtures of fine and coarse aggregates for various types of construction, including concrete, when the sizes larger than No. 4 are specified on the basis of sieves with square openings.

STANDARD DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY

(A.S.T.M. DESIGNATION: C 11 – 28)[2]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 31 T)"[3] are intended to be added when adopted to the present standard definitions.

STANDARD DEFINITION OF THE TERM SAND

(A.S.T.M. DESIGNATION: C 58 – 28)[4]

The Tentative Definition of the Term Aggregate (C 58 – 28 T)[5] is intended to be included, when adopted, with the present Standard Definition of the Term Sand.

STANDARD DEFINITIONS OF TERMS RELATING TO REFRACTORIES

(A.S.T.M. DESIGNATION: C 71 – 31)[6]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Heat Transmission of Refractories (C 71 – 31 T)"[7] are intended to be added when adopted to the present standard definitions.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. R. Litehiser, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Ohio State Highway Dept., Columbus, Ohio.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 749 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 365.

[4] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. E. Hess, Secretary of Committee E-8 on Nomenclature and Definitions, 1315 Spruce St., Philadelphia, Pa.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 835 (1928); also 1932 Book of A.S.T.M. Tentative Standards, p. 399.

[6] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. C. E. Bales, Secretary of Committee C-8 on Refractories, Ironton Fire Brick Co., Ironton, Ohio.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 779 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 415.

D. MISCELLANEOUS MATERIALS

STANDARD SPECIFICATIONS FOR BASIC CARBONATE WHITE LEAD

(A.S.T.M. DESIGNATION: D 81 - 31)[1]

Section 2. (*a*) *Dry Pigment.*—Change this section to read as follows by the omission of the words in brackets and the addition of the italicized word:

2. (*a*) Dry Pigment.—The pigment [shall be the product made from metallic lead and] shall have a composition [corresponding approximately to] *approximating* the formula $2PbCO_3.Pb(OH)_2$. It [shall be thoroughly washed after corroding], shall be free from impurities [and adulterants], and shall meet the requirements given in Section 3.

STANDARD SPECIFICATIONS FOR BROKEN SLAG FOR WATERBOUND BASE AND WEARING COURSE

(A.S.T.M. DESIGNATION: D 65 - 23)[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 12.0 per cent.

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[Retained on] *Passing* 2½-in screen . . . not [less] *more* than [85] *15* per cent.

Section 7 (*b*).—Omit this paragraph which refers to the method for determining the percentage of wear.

STANDARD SPECIFICATIONS FOR SHOVEL-RUN OR CRUSHER-RUN BROKEN SLAG FOR WATERBOUND BASE

(A.S.T.M. DESIGNATION: D 66 - 23)[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 15.0 per cent.

Section 6 (*b*).—Omit this paragraph which refers to the method for determining the percentage of wear.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

STANDARD SPECIFICATIONS FOR BLOCK FOR GRANITE BLOCK PAVEMENTS

(A.S.T.M. DESIGNATION: D 59 - 26)[1]

Section 3 (a).—Change to read as follows by the addition of the italicized words:

3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation D 2) of the American Society for Testing Materials, ***except that the sample shall be prepared by use of a press and the fragments shall be as uniform and as nearly cubical as practicable.***

STANDARD SPECIFICATIONS FOR BLOCK FOR RECUT GRANITE BLOCK PAVEMENTS

(A.S.T.M. DESIGNATION: D 131 - 23)[1]

Section 3 (a).—Make the same change as in Section 3 (*a*) of Specifications D 59 - 26 above.

STANDARD SPECIFICATIONS FOR BLOCK FOR DURAX GRANITE PAVEMENTS

(A.S.T.M. DESIGNATION: D 132 - 23)[1]

Section 3 (a).—Make the same change as in Section 3 (*a*) of Specifications D 59 - 26 above.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR COTTON SEWING THREADS

(A.S.T.M. DESIGNATION: D 204 - 27)[2]

Section 5.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

5. The finished sewing thread shall be balanced in twist as nearly as possible [and in no case shall a yard of thread when drawn from the side of a spool or package twist upon itself more than six times when brought together to form a loop] ***to eliminate breakage from kinks during the sewing operation.***

Section 8.—Replace the second, third and fourth sentences of this section, which read as follows:

Any yarn reel having a $1\frac{1}{2}$-yd. perimeter may be used in preparing the skeins. On reels that have only one pigtail guide, tension shall be applied by making one full wrap of the thread around the guide. On reels using two or more guides, the thread shall pass straight through the guides onto the reel, the angles of the guides supplying the necessary tension.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

by the following sentence:

Any yarn reel having a $1\frac{1}{2}$-yd. perimeter may be used in preparing the skeins, and tension shall be applied by making either two or three full wraps of the thread around the pigtail guide and reeled at a speed to lay the thread sufficiently taut on the reel.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR ASBESTOS YARNS

(A.S.T.M. DESIGNATION: D 299 – 29)[1]

Title.—Change the title of these specifications to read as follows by the omission of the words in brackets:

Standard Specifications for [Tolerances and Test Methods for] Asbestos Yarns.

Section 2.—Change Paragraphs (*a*) and (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

2. (a) Asbestos Yarn.—Asbestos yarn is yarn consisting of: (1) asbestos fiber, (2) asbestos and [cotton] *vegetable* fibers, or (3) asbestos and [cotton] *vegetable* fibers and wire.

(b) Plain Asbestos Yarn.—Plain asbestos yarn is yarn consisting of: (1) asbestos fiber, or (2) asbestos and [cotton] *vegetable* fibers.

Change Paragraph (*e*) to read as follows by the addition of the italicized word:

(e) Ply.—In the case of asbestos yarn, ply is the number of strands of single *asbestos* yarn twisted together to form a heavier yarn.

Section 5.—Add a new Grade A-1 of asbestos yarn to this section and change the present grades so as to specify the percentage of asbestos content instead of the cotton content, thus changing this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

5. (a) The [cotton] *asbestos* content of both plain asbestos yarn and of metallic asbestos yarn shall conform to the following requirements:

Grade A-1....................	*77 per cent, minimum*
Grade A[a]....................	[15 to 20] *80 to 85* per cent
Grade AA....................	[8 to 10] *90 to 92* per cent
Grade AAA..................	[4 to 5] *95 to 96* per cent
Grade AAAA................	[none] *100 per cent minus, tolerating a trace of foreign matter*

[a] *Grade A meets Underwriters Laboratories' requirements.*

(b) The [cotton] *asbestos* content of metallic asbestos yarn shall be determined after all the wire has been removed from the test specimen.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

Sections 6 and 7.—Replace the present absorption method for determining cotton content by the following electric-furnace method:

6. *Electric-Furnace Method.*—Dry a 1-oz. sample of asbestos yarn in a weighed crucible at 212° F. (100° C.) to constant weight. Ignite in an electric furnace at 1600° F. (871° C.) for 1 hour. Cool in a desiccator to room temperature and weigh. Divide the weight of ash by the factor 0.86[a] to determine original weight of asbestos fiber. To obtain the percentage of asbestos, divide the weight of asbestos by the weight of dried sample.

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[a] This factor is based upon a proved average of 14-per-cent water-of-crystallization in Chrysotile asbestos.

STANDARD SPECIFICATIONS FOR TEXTILE TESTING MACHINES

(A.S.T.M. DESIGNATION: D 76 – 27)[1]

Section 5 (a) Fabric Jaws.—Add a new paragraph to read as follows:

In the case of vertical or upright testing machines, where the upper jaws are not held in positive alignment, it is recommended that the lower jaw of the testing machine be provided with two tapered pins one on each side about ⅓ in. in diameter which project upward and are adjustable for different spacing between the top and bottom jaws. The upper ends of these pins shall fit into the tapered holes in the upper jaw when placing the specimen but disengaging when the jaws separate. In this way they regulate the distance between the jaws and hold them in positive alignment while the test specimen is being inserted.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR ELECTRICAL SILK AND COTTON TAPES

(A.S.T.M. DESIGNATION: D 259 – 27)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Tolerances and Test Methods for Silk and Cotton Tapes (D 259 – 31 T)"[2] is intended to replace when adopted the present standard specifications.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR CERTAIN LIGHT AND MEDIUM COTTON FABRICS

(A.S.T.M. DESIGNATION: D 274 – 29)[1]

New Section.—Add the following new test procedure as Section 8:

TEAR RESISTANCE

8. (*a*) *Preferred Method.*—A specimen 3 in. in width and 8 in. in length shall be selected for test. A longitudinal cut 3 in. in length shall be made in the

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 990 (1931); also 1932 Book of A.S.T.M. Tentative Standards, p. 1021.

center of the specimen. One of the tongues thus formed shall be placed in the upper jaw of a tensile strength testing machine, preferably with automatic recording device, and the other in the lower jaw. The machine shall then be started and the specimen torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered to be the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

(*b*) *Alternate Method.*—A specimen 3 in. in width and 6 in. in length shall be selected for test. An isosceles trapezoid having an altitude of 3 in. and with bases 1 in. and 4 in. in length, respectively, shall then be marked on the specimen with the aid of a template. A cut ¼ to ⅜ in. in length shall then be made in the center of the 1-in. length and perpendicular to it. The specimen shall then be clamped in the jaws of the tensile strength testing machine along the non-parallel sides of the trapezoid. The initial distance between the jaws shall be 1 in., and the width of the jaws shall be 3 in. or more. One edge of the specimen shall thus be held taut while the other edge lies in folds. The machine shall then be started and the sample torn, the speed of the pulling jaw being 3 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered as the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

STANDARD GENERAL METHODS OF TESTING WOVEN TEXTILE FABRICS

(A.S.T.M. DESIGNATION: D 39 – 27)[1]

New Section.—Add as a new Section 14 the tear resistance test procedure recommended in Specifications D 274 – 29 above.

STANDARD METHODS OF ROUTINE ANALYSIS OF WHITE PIGMENTS

(A.S.T.M. DESIGNATION: D 34 – 30)[2]

Change section heading "General Method" to read "General Methods" and add the following new paragraph:

Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N.Y.

Omit the entire section under Basic Sulfate of Lead and substitute the following methods:

BASIC SULFATE OF LEAD

Qualitative Analysis.—Test for matter insoluble in acid ammonium acetate solution, for calcium, for carbonates, and for any other impurities suspected, by the regular methods of qualitative analysis.

Moisture.—Place 1 g. of the sample in a tared, wide-mouth, short, weighing tube provided with a glass stopper. Heat with stopper removed for 2 hours at a temperature between 105 and 110° C. Insert stopper, cool and weigh. Calculate loss in weight as moisture.

Insoluble Impurity and Total Lead.—In a 250-cc. beaker, moisten 1 g. of the pigment with a few drops of alcohol; add 50 cc. of acid ammonium acetate solution (made by mixing 150 cc. of 80 per cent acetic acid, 100 cc. of water, and 95 cc. of ammonium hydroxide (sp. gr. 0.90)). Heat to boiling and boil for 2 minutes. Decant through a filter paper leaving any undecomposed matter in the beaker. To the residue in the beaker, add 50 cc. of the acid ammonium acetate solution, heat to boiling and boil for 2 minutes. Filter through the same paper and wash with hot water. If an appreciable residue remains, ignite and weigh as insoluble impurity. Unite the acid ammonium acetate solutions, heat to boiling, and add dropwise, while stirring, a slight excess (in total about 10 to 15 cc.) of a 10 per cent solution of potassium dichromate. Heat until the precipitate assumes an orange color, let settle, filter on a weighed Gooch crucible, wash by decantation with hot water until the washings are colorless, and finally transfer all of the precipitate to the crucible. Then wash with 10 cc. of 95 per cent ethyl alcohol and finally with 10 cc. of ethyl ether. Dry at 105 to 110° C., cool, and weigh $PbCrO_4$. Calculate to PbO by multiplying by the factor 0.69.

Zinc Oxide.—Weigh accurately about 1 g. of the pigment, transfer to a 400-cc. beaker, add 30 cc. of HCl (1:2), boil for 2 or 3 minutes, add 200 cc. of water and a small piece of litmus paper, add NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with standard potassium ferrocyanide as in standardizing that solution. Calculate total zinc as ZnO.

The standard potassium ferrocyanide solution is prepared and standardized as follows: Dissolve 22 g. of the pure salt in water and dilute to 1000 cc. and mix. To standardize, transfer about 0.2 g. (accurately weighed) of pure metallic zinc or freshly ignited pure ZnO to a 400-cc. beaker. Dissolve in 10 cc. of HCl and 20 cc. of water. Drop in a small piece of litmus paper, add NH_4OH until slightly alkaline, then add HCl until just acid and finally add 3 cc. of strong HCl. Dilute to about 250 cc. with hot water and heat nearly to boiling. Run in the ferrocyanide solution slowly from a burette with constant stirring until a drop tested on a white porcelain plate with a drop of the uranyl indicator (a 5 per cent solution of uranyl nitrate in water or a 5 per cent solution of uranyl acetate in water made slightly acid with acetic acid), shows a brown tinge after standing 1 minute. A blank should be run with the same amounts of reagents and water as in the standardization. The amount of ferrocyanide solution required for the blank should be subtracted from the amounts used in standardization and in titration of the sample. The standardization must be made under the same conditions of temperature, volume, and acidity as obtained when the sample is titrated.

Lead Sulfate.—Treat 0.5 g. of the pigment in a 400-cc. beaker with a few drops of alcohol, add 10 cc. of bromine water, 10 cc. of HCl (1:1) and 3 g. of NH_4Cl. Cover with a watch glass and heat on a steam bath for 5 minutes, add hot water to give a total volume of about 200 cc. boil for 5 minutes, filter to separate any insoluble matter (a pure pigment should be completely dissolved), and wash thoroughly with hot water. (The insoluble matter may be ignited, weighed, and examined qualitatively.) Neutralize the clear solution (original solution or filtrate from insoluble matter) in a covered beaker with dry Na_2CO_3, add 1 g. more of dry Na_2CO_3, and boil 10 to 15 minutes. Wash off cover, let settle, filter, and wash with hot water. Redissolve the precipitate in HCl (1:1), reprecipitate with Na_2CO_3 as above, filter, and wash thoroughly with hot water. Acidify the united filtrates with HCl, adding about 1 cc. in excess. Boil to expel bromine, and to the clear boiling solution add slowly while stirring 15 cc. of 10 per cent barium chloride solution. Let stand on steam bath for about 1 hour, filter on a weighed Gooch crucible, wash thoroughly with boiling water, dry, ignite, cool, and weigh as $BaSO_4$. Calculate to $PbSO_4$, using the factor 1:3.

Calculations.—Calculate the percentage of $PbSO_4$ to PbO by multiplying by the factor 0.736 and subtract the result from the percentage of PbO found under *Insoluble Impurity and Total Lead;* report the difference as PbO. Report ZnO found under *Zinc Oxide* as percentage of ZnO. Moisture and insoluble matter are reported as such.

Zinc-Lead and Leaded-Zincs.—Under first section headed *Total Lead and Zinc,* in next to last sentence after the words "potassium-ferrocyanide solution" add the phrase "as described under basic sulfate of lead."

Zinc Oxide.—Under section headed *Total Zinc,* at end of first sentence for the words "by Low" substitute "as described under basic sulfate of lead." In the last sentence add a footnote reference number two after "Low."

Lithopone.—Under section headed *Insoluble and Total Zinc,* in next to last sentence for the words "under zinc white" substitute "described under basic sulfate of lead."

Change section headed *Zinc Oxide* to read as follows:

Weigh accurately 1 g. of the lithopone, transfer to a 250-cc. beaker (moisten with a few drops of alcohol if an extracted pigment), add about 100 cc.

of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$, as described under basic sulfate of lead. Calculate to ZnO. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.)

STANDARD METHODS OF ROUTINE ANALYSIS OF WHITE LINSEED OIL PAINTS

(A.S.T.M. DESIGNATION: D 215 – 29)[1]

Testing Non-Volatile Vehicle.—At the end of Section *A*, *Preparation of Fatty Acids*, add the following new paragraph:

Instead of the preceding method the following procedure may be used, especially with samples that give trouble by the former: To about 50 g. of paint in a porcelain casserole, add 30 cc. of aqueous 30 per cent NaOH and 125 cc. of ethyl alcohol, mix and evaporate on steam bath until residue is dry. Transfer to a 400-cc. beaker and boil with 200 cc. of water, add H_2SO_4 (sp. gr. 1.2) (25 cc. in excess), boil, stir, filter through large coarse paper, and drain. Scrape mass into a flask, shake violently with ether, centrifuge, decant into a separatory funnel, and wash with small amounts of water until free of H_2SO_4. Transfer ether solution to dry flask and leave over about 40 g. of anhydrous sodium sulfate until ether layer is clear. Decant the clear solution through filter paper into a dry 100-cc. flask. Pass a rapid current of dry air into the mouth of the flask and heat to a temperature below 75° C. on a dry hot plate until the ether is entirely removed. The fatty acids prepared as above should be kept in a stoppered flask and examined at once.

Under Section (2), Mixed or Composite Pigments, in the paragraph on *Insoluble Matter*, add the following sentence between the fourth and fifth sentences from the end of the first paragraph:

In order to make sure that practically no silica is occluded by the $BaSO_4$ as finally weighed, especially with pigments high in siliceous matter, the following step may be taken at this point: Evaporate the HCl solution to dryness, and heat at about 150° C. for one-half to one hour; moisten the residue with concentrated HCl, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper, and wash thoroughly with hot water.

Also under (2) Mixed or Composite Pigments, in the second paragraph under "Total Lead (Antimony)," change the seventh sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[Moisten the residue with a few drops of HCl,] *To the residue add sufficient concentrated HCl to dissolve the $PbSO_4$ (with pigments containing considerable amounts of $PbSO_4$, it may be necessary to add 15 to 20 cc. of concentrated HCl)*, add about 50 cc. of hot water, boil a few minutes, filter hot through paper, and wash with hot water until washings give no test for lead.

In the procedure for *Total Zinc* under B. Quantitative Analysis, (2) Mixed or Composite Pigments, change Paragraph (*d*) to read as follows:

(*d*) With pigments containing ZnO and ZnS, the ZnO may be determined as follows: Weigh accurately 1 g. of the pigment, transfer to a 250-cc. beaker, moisten with alcohol, add about 100 cc. of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$ solution as above. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.)

In the last sentence of the fourth paragraph at the end of the methods change the footnote to the procedure of the Federal Specifications Board to read as follows:

Federal Specifications Board, Federal Specification TT-P-36 for Paints; Lead-Zinc Base, Ready-Mixed and Semipaste, White and Tinted, p. 2: "The total lead dissolved in dilute acetic acid and hot ammonium acetate, weighed as lead sulfate, and this weight multiplied by the factor 0.883 shall be considered white lead. It is not possible to determine the amount of lead carbonate and lead sulfate when carbonates or sulfates or other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds. The factor to convert $PbSO_4$ to $(PbCO_3)_2Pb(OH)_2$ is 0.854, to convert $PbSO_4$ to $PbSO_4PbO$ is 0.868, and to convert $PbSO_4$ to $(PbSO_4)_2PbO$ is 0.913. The arbitrary factor used under this specification is the mean of the largest and smallest of these factors."

STANDARD METHODS OF ROUTINE ANALYSIS OF DRY RED LEAD

(A.S.T.M. DESIGNATION: D 49 – 29)[1]

Add the following paragraph as a new Section 2, renumbering the present sections accordingly:

2. *Treatment of Sample.*—If the pigment is lumpy or not finely ground, it shall be ground to a fine powder and thoroughly mixed. Large samples may

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be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. All samples shall be preserved in stoppered bottles or containers.

STANDARD METHODS OF ROUTINE ANALYSIS OF YELLOW, ORANGE, RED, AND BROWN PIGMENTS CONTAINING IRON AND MANGANESE

(A.S.T.M. DESIGNATION: D 50 - 27)[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Section 14.—Change the first sentence of the third paragraph to read as follows by the addition of the italicized words:

The NH_4OH precipitate is dissolved in hot dilute HCl, washing paper with hot water, cooled, oxidized with Na_2O_2, boiled *vigorously for 10 to 15 minutes* to expel H_2O_2, cooled, cover glass washed off, diluted to about 150 cc., and acidified with H_2SO_4.

STANDARD METHODS OF ROUTINE ANALYSIS OF YELLOW AND ORANGE PIGMENTS CONTAINING CHROMIUM COMPOUNDS, BLUE PIGMENTS AND CHROME GREEN

(A.S.T.M. DESIGNATION: D 126 - 27)[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Section 7.—Change the ninth sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

[Render an aliquot portion acid with H_2SO_4, boil to expel any free oxygen, cool,] *Boil an aliquot portion vigorously for 10 to 15 minutes to expel H_2O_2, cool, acidify with H_2SO_4,* add an excess of standard $(NH_4)_2Fe(SO_4)_2.6H_2O$ solution and titrate back with 0.1 *N* $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ as outside indicator.

Also in this section change the second from the last sentence in the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

If iron or aluminum are not to be determined or are present in negligible amounts, the first NH_4OH precipitate may be dissolved in dilute HCl, oxidized with Na_2O_2, [acidified with H_2SO_4, boiled,] *boiled vigorously for 10 to 15 minutes to expel H_2O_2, cooled, acidified with H_2SO_4,* and CrO_3 determined volumetrically.

Section 11.—In the third sentence change "20 cc." to read "25 cc."

Section 22.—Change from its present form: namely,

22. Make the test for water-soluble matter in accordance with Section 11.

to read as follows:

22. Transfer 2.5 g. of the pigment to a graduated 250-cc. flask, fill to the mark with water and stopper. Shake vigorously and let stand at room temperature for not less than 15 hours, shaking vigorously from time to time. Then let settle, filter through a dry filter paper and discard the first 25 cc. of the filtrate. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam bath, dry for one hour in an oven at 105 to 110° C., cool and weigh. Calculate the percentage of water-soluble matter.

Section 38.—Change to read as follows by the addition of the italicized words:

38. On a separate sample determine the sulfate directly with Na_2CO_3 as in the preceding paragraph, without any preliminary treatment with bromine water *or nitric acid.*

Section 53.—Change the reference from "Section 11" to read "Section 22."

New Methods.—Add the following Methods of Analysis of Chrome Oxide Green as Sections 55 to 57:

METHODS OF ANALYSIS OF CHROME OXIDE GREEN

Chrome oxide green is practically pure sesquioxide of chromium (Cr_2O_3) without any admixture.

Moisture

55. Determine moisture in accordance with Section 45.

Water-Soluble Matter

56. Determine water-soluble matter in accordance with Section 11.

Total Chromium

57. Mix thoroughly about 0.25 g. (accurately weighed) of the sample with approximately 5 g. of sodium peroxide (containing at least 90 per cent Na_2O_2) in a 30-cc. pure iron crucible (ordinary iron crucibles may contain some chromium and manganese) and fuse carefully over a gas flame. Five minutes fusion at a low red heat after the mass has melted will insure complete decomposition. Allow the crucible to partly cool, and while tightly covered, tap on an iron plate to loosen the fusion in a solid cake. Place the cake in a covered beaker and dissolve with 200 cc. of warm water. Rinse the crucible and cover with warm water, adding to the main portion. Add approximately 1 g. of sodium peroxide and boil the solution for 10 minutes. Cool and acidify with sulfuric acid (50 cc., 1:1 sulfuric acid). A clear solution with a few scales of magnetic oxide should result. Immediately cool again, add 5 cc. of phosphoric acid (sirup, sp.gr. 1.725), transfer to an 800-cc. beaker and dilute with cold water to 500 cc. Add an accurately measured excess (about 100 cc.) of approximately 0.1 *N* ferrous ammonium sulfate to the solution while stirring. When reduction is complete a deep pure green color should develop, and a drop of the liquid when tested with a drop of dilute potassium ferricyanide solution should give a blue color. Set the beaker about ½ in. above a white tile to secure good light. Determine the excess of ferrous sulfate by titration with a standard solution (approximately 0.1 *N*) of potassium permanganate. Take the first faint permanent darkening of the clear green color as the end point. Addition of more permanganate increases the depth of the color which finally becomes purple. The end point is quite sharp and well defined, but requires some practice. If the ferrous salt has been standardized against dichromate, subtract the required number of cubic centimeters of 0.1 *N* permanganate from the number of cubic centimeters of 0.1 *N* ferrous solution. The difference represents the number of cubic centimeters of 0.1 *N* ferrous solution which multiplied by 0.001733 g. gives the grams of chromium present. Where the ferrous solution has been standardized against sodium oxalate, it is necessary to substract a "blank" from the permanganate titration. This blank" is obtained as follows: When the end point is reached and the readings have been noted, add about 5 cc. excess of the ferrous solution and oxidize the excess of ferrous iron by adding 8 cc. of a 15 per cent solution of ammonium persulfate. Stir the liquid vigorously for one minute. Carefully add 0.1 *N* permanganate to the solution with constant stirring until the same end point is obtained as before. The volume of permanganate required, usually 0.2 to 0.4 cc., constitutes the "blank" to be deducated from the volume of the permanganate titration.

NOTE.—*Example:* In the determination of chromium in a 0.5000-g. sample 190.0 cc. of a 0.11 *N* ferrous solution and 11.00 cc. of a 0.1 *N* permanganate (11.40 – 0.4 cc. blank) were employed. The calculations are as follows:

$190.0 \times 1.100 = 209.0$ cc. of 0.1 *N* ferrous solution;

$209.0 - 11.00 = 198.00$ cc.

$198.0 \times 0.001733 \times 2 \times 100 = 68.62$ per cent Cr.

STANDARD METHODS OF ROUTINE ANALYSIS OF TITANIUM PIGMENTS

(A.S.T.M. DESIGNATION: D 186 - 29)[1]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

> 1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

STANDARD METHODS OF TEST FOR HYGROSCOPIC MOISTURE (AND OTHER MATTER VOLATILE UNDER THE TEST CONDITIONS) IN PIGMENTS

(A.S.T.M. DESIGNATION: D 280 - 31)[2]

Section 4.—Change the seventh sentence from its present form: namely,

> Admit air slowly to the desiccator by means of the pinch-cock or stop-cock, remove the cover, replace the stopper in the weighing bottle and weigh.

to read as follows:

> Admit air, that has been dried by passage through *fresh* magnesium perchlorate trihydrate, slowly to the desiccator by means of the pinch-cock or stop-cock, remove the cover, quickly replace the stopper in the weighing bottle and weigh.

Explanatory Notes.—After the word "pump" in Section 3 (*b*) insert "(Note 1)." Place the present note at the end of the methods numbering it as Note 1 under a central heading Explanatory Notes.

At the end of Section 3 (*d*) insert "(Note 2)" and place the present note at the end of the methods as Note 2.

After the word "constant" in Section 4 insert "(Note 3)." Transpose the present note to the end of the methods as Note 3.

At the end of Section 4 insert "(Note 4)." Add the following Note 4 to the Explanatory Notes:

> Note 4.—This is an arbitrary method and the details should be strictly followed. The determination of the true hygroscopic moisture content of very finely divided pigments is very difficult, if not impossible in some cases.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

STANDARD METHOD OF ROUTINE ANALYSIS OF DRY CUPROUS OXIDE

(A.S.T.M. DESIGNATION: D 283 - 29)[1]

Add the following paragraph as a new Section 1, renumbering the present Sections 1 and 2 as Sections 2 and 3:

1. Treatment of Sample.—If the pigment is lumpy or not finely ground, it shall be ground to a fine powder and thoroughly mixed. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample shall in all cases be thoroughly mixed before taking portions for analysis. All samples shall be preserved in stoppered bottles or containers.

STANDARD METHOD OF ROUTINE ANALYSIS OF DRY MERCURIC OXIDE

(A.S.T.M. DESIGNATION: D 284 - 29)[1]

Make the same change in this method as recommended in Method D 283 - 29 above.

STANDARD METHODS OF TEST FOR VISCOSITY OF PETROLEUM PRODUCTS AND LUBRICANTS

(A.S.T.M. DESIGNATION: D 88 - 30)[2]

Section 3 (b).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

(*b*) With the Saybolt Furol Viscosimeter, determinations shall be made at 77, *100*, 122, or [212] *210*° F. (25, *37.8*, 50 or [100] *98.9*° C.).

STANDARD METHOD OF TEST FOR FLASH AND FIRE POINTS BY MEANS OF OPEN CUP

(A.S.T.M. DESIGNATION: D 92 - 24)[2]

Section 2.—Add the following paragraphs and table as a new Section 2 and Paragraph (*a*) and reletter the present Section 2 as Paragraph (*b*):

2. The Cleveland open cup, a diagram of which appears in Fig. 1, (the accompanying Fig. 2), shall include the following major parts:

(*a*) *Flash Cup.*—The cup shall be made of brass and shall conform to the following requirements:

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. P. Anderson, American Petroleum Inst., 250 Park Ave., New York City.

	INCHES			CENTIMETERS		
	MINIMUM	NORMAL	MAXIMUM	MINIMUM	NORMAL	MAXIMUM
Inside diameter immediately below filling mark	$2\frac{15}{32}$	$2\frac{1}{2}$	$2\frac{17}{32}$	6.27	6.35	6.43
Outside diameter below flange	$2\frac{21}{32}$	$2\frac{11}{16}$	$2\frac{23}{32}$	6.75	6.83	6.91
Inside height from center of bottom to rim	$1\frac{9}{32}$	$1\frac{5}{16}$	$1\frac{11}{32}$	3.25	3.33	3.41
Thickness of bottom	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	0.28	0.32	0.36
Distance from rim to filling mark	$\frac{23}{64}$	$\frac{3}{8}$	$\frac{25}{64}$	0.91	0.95	0.99
Distance lower surface flange to bottom of cup	$1\frac{7}{32}$	$1\frac{1}{4}$	$1\frac{9}{32}$	3.10	3.18	3.26
Vertical distance upper surface flange to rim.	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	0.28	0.32	0.36
Thickness of rim	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	0.20	0.24	0.28
Width of lower surface of flange	$\frac{9}{16}$	$\frac{19}{32}$	$\frac{5}{8}$	1.43	1.51	1.59

The bevelled edge of the cup shall be at an angle of approximately 45 deg. There may be a fillet of approximately $\frac{5}{32}$ in. (0.397 cm.) radius inside the bottom of the cup.

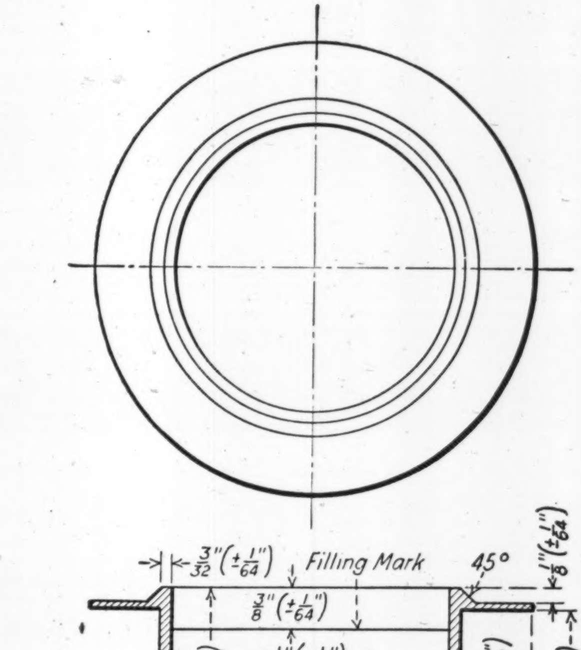

FIG. 2.—Cleveland Open Cup.

Flash Cup.—Substitute the accompanying Fig. 2 for Fig. 1 in the present method.

Section 4 (b).—Change to read as follows by the addition of the italicized words and figures:

> (*b*) The cup shall be filled with the oil to be tested in such a manner that the top of the meniscus is exactly at the filling line at room temperature. ***When asphalt or other solid bituminous material is to be tested, it shall first be heated to a temperature not less than 300° F. nor more than 350° F., to render it sufficiently fluid. The cup shall then be filled with the hot fluid at this temperature in the same manner as with oil. The subsequent procedure shall then be the same for both asphalt and solid bituminous material as with oil.*** The surface of the oil shall be free from bubbles. There shall be no oil above the filling line or on the outside of the apparatus.

STANDARD METHOD OF TEST FOR CLOUD AND POUR POINTS

(A.S.T.M. DESIGNATION: D 97 – 30)[1]

Section 11.—Change the third sentence of the third paragraph to read as follows by the addition of the italicized word and numbers and the omission of those in brackets:

> Oils on which a [very low] pour point *below −30° F.* is expected shall be heated as above with the high cloud- and pour-test thermometer in position, cooled to 60° F. and the low cloud- and pour-test thermometer placed in position, and the assembly placed in the jacket.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COAL AND COKE

(A.S.T.M. DESIGNATION: D 271 – 30)[2]

A revision in the form of a separate tentative method entitled "Method of Sampling Coal by Ball-Mill Method (D 271 – 32 T)"[3] is intended when adopted to be incorporated in the present standard methods.

STANDARD METHODS OF SAMPLING AND ANALYSIS OF CREOSOTE OIL

(A.S.T.M. DESIGNATION: D 38 – 30)[4]

Section 4.—Change the last sentence of the first paragraph to read as follows by the addition of the italicized figure and the omission of the words and figure in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, American Petroleum Inst., 250 Park Ave., New York City.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[3] See p. 794.

[4] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

If more than [2] *3* per cent of water is present, [or if the water is apparently present to an extent in excess of 2 per cent, but an accurate separation is impossible,] the percentage of water present shall be determined by the following method, and the water-free oil so obtained shall be used in the distillation test:

Section 9.—Replace the second and third sentences: namely,

In case the oil requires to be brought to a higher temperature than 38° C. in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by adding 0.0008 to the observed specific gravity for each degree Centigrade above 38° C. at which the test is made. This correction factor does not apply with equal accuracy to all oils, but serious error due to its use will be avoided if the foregoing precaution is observed, with respect to avoiding unnecessarily high temperature.

by a single sentence reading as follows:

In case it is necessary to bring the oil to a higher temperature than 38° C. in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by selecting the appropriate factor from Tables I and II shown in the Tentative Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (A.S.T.M. Designation: D 347- 32 T) of the American Society for Testing Materials.[1]

New Test Procedure.—The Tentative Method for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 - 30 T)[2] is intended to be incorporated, when adopted, in the present Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 30).

STANDARD METHOD OF TEST FOR DISTILLATION OF CREOSOTE OIL

(A.S.T.M. DESIGNATION: D 246 - 30)[3]

Section 8.—Change the phase "If the presence of water is suspected or known" to read "If the presence of 3 per cent of water is suspected or known."

Section 10.—Add a new paragraph to read as follows:

(*f*) If the fraction 0 to 210° C. contains water the amount of water shall be determined. This amount shall then be deducted from the weight of oil taken and all of the fractions shall be corrected to a percentage based on dry oil. A convenient method for determining the amount of water is to transfer this fraction, after weighing, to a tube or cylinder graduated in 0.1 cc. and add benzol. This almost always causes a clear separation between the oil and water.

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[1] See p. 797.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30,Part I, p. 1152 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 718.

[3] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

STANDARD METHODS OF TESTING MOLDED MATERIALS USED FOR ELECTRICAL INSULATION

(A.S.T.M. DESIGNATION: D 48 – 30)[1]

Section 4 (*a*).—Change from its present form: namely,

4. (*a*) Five specimens shall be tested in the condition in which they are received.

to read as follows:

4. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours followed by cooling to room temperature in a desiccator. Five specimens shall be tested at room temperature.

Section 8 (*a*).—Change the first sentence from its present form: namely,

8. (*a*) Five specimens shall be crushed in the condition in which they are received.

to read as follows:

8. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours, followed by cooling to room temperature in a desiccator. Five specimens shall be crushed at room temperature.

Section 12 (*a*).—Change the first sentence from its present form: namely,

12. (*a*) Five specimens shall be tested in the condition in which they are received.

to read as follows:

12. (*a*) All specimens shall be conditioned before testing by drying in an oven at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours followed by cooling to room temperature in a desiccator. Five specimens shall be tested at room temperature.

Section 22.—Change this section to read as follows by the addition of the italicized figures and the omission of those in brackets:

22. Any good chemical balance, a beaker of water at [25° C. ± 5° C. (77° F. ± 9° F.)] *25° C. ± 2° C. (77° F. ± 3.6° F.)*, and an oven of any standard make capable of maintaining a uniform temperature of 100° C. ± 5° C. (212° F. ± 9° F.).

Section 24.—Change the next to the last sentence of this section to read as follows by the addition of the italicized figures and the omission of those in brackets:

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

The specimens shall be placed in water, wholly immersed, for 48 hours at a temperature of [25° C. ± 5° C. (77° F. ± 9° F.)] *25° C. ± 2° C. (77° F. ± 3.6° F.)*.

STANDARD METHODS OF TESTING ELECTRICAL INSULATING OILS

(A.S.T.M. DESIGNATION: D 117 - 31)[1]

Insert a new Section 17, reading as follows, renumbering the present Sections 17, 18 and 19 as Sections 18, 19 and 20, respectively:

STEAM EMULSIFICATION TEST

17. The steam emulsification test shall be determined in accordance with the Standard Method of Test for Steam Emulsification of Lubricating Oils (A.S.T.M. Designation: D 157) of the American Society for Testing Materials.

STANDARD DEFINITIONS OF TERMS RELATING TO PAINT SPECIFICATIONS

(A.S.T.M. DESIGNATION: D 16 - 24)[2]

Add the following three new definitions of terms:

***Screen* (*Sieve*).—A plate or sheet or a woven cloth, or other device, with regularly spaced apertures of uniform size, mounted in a suitable frame or holder, for use in separating material according to size.**

NOTE 1.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be taken care of in specifications.

NOTE 2.—In mechanical analysis testing work, when not otherwise specified, the term "sieve" shall apply to an apparatus in which the apertures are rectangular, and the term "screen" shall apply to an apparatus in which the apertures are circular.

***Toughness*.—That quality of a material which may be measured by the maximum impact which it will withstand without rupture.**

***Elasticity*.—In the case of paint or varnish, that property which allows a film to follow, without rupture, changes in the extent and form of the surface to which it is applied.**

STANDARD DEFINITIONS OF TERMS RELATING TO COAL AND COKE

(A.S.T.M. DESIGNATION: D 121 - 30)[3]

The Tentative Definition of the Term Coke (D 121 - 30 T)[4] is intended to be added, when adopted, to the present standard definitions.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. M. Rea Paul, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[3] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol.30, Part I, p. 1147 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 713.

STANDARD DEFINITIONS OF TERMS RELATING TO TEXTILE MATERIALS

(A.S.T.M. DESIGNATION: D 123 – 30)[1]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T)"[2] are intended to be added, when adopted, to the present standard definitions.

E. MISCELLANEOUS SUBJECTS

STANDARD DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING

(A.S.T.M. DESIGNATION: E 6 – 30)[3]

The definitions of the terms "elastic limit" and "yield strength" published under the title "Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T)"[4] are intended to be added, when adopted, to the present standard definitions.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Box 28, East Side Station, Providence, R. I.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1254 (1930); also 1932 Book of A.S.T.M. Tentative Standards, p. 1070.

[3] 1930 Book of A.S.T.M. Standards, Part I or Part II. Criticisms of this revision are solicited and should be directed to Mr. H. F. Moore, Chairman of the Subcommittee on Mechanical Testing of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

[4] See p. 967.

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